GIBSON NATURE STUDIES

W Hamilton Gibson

BLOSSOM HOSTS AND INSECT GUESTS

HOW THE HEATH FAMILY, THE BLUETS, THE FIGWORTS, THE ORCHIDS AND SIMILAR WILD FLOWERS WELCOME THE BEE THE FLY, THE WASP, THE MOTH AND OTHER FAITHFUL INSECTS

By

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PUBLISHERS' NOTE

WE are indebted to the courtesy of Messrs. Harper & Brothers, the publishers of Mr. William Hamilton Gibson's books, for permission to compile this volume from the work of that distinguished author and artist.

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PREFACE

"BLOSSOM HOSTS AND INSECT GUESTS" is an exposition of the method by which flowers are fertilized, a subject which Mr. Gibson was the first American to investigate, his patient study resulting in many valuable contributions to scientific knowledge in this direction.

"No one knew more of flowers, shrubs, trees and insects or of the special haunts and homes of all of them, and even readers to whom botany is a sealed book may follow him into the fields and woods and marshes with a full certainty of being charmed and enlightened in unexpected ways. He was his own teacher in what was best, and those who have the task of training amateur naturalists should see well to it that they catch, if they can, the secret of his success."

He not only ranked high as a scientist, but undoubtedly stood at the head of the artist-writers of our country, "his graceful, poetical prose being nearly of equal value with his fine and delicate drawings. His style is full of glowing freshness. His

mind springs beyond the hackneyed and commonplace. His genius is of the imaginative order."

The results of his researches, embodied in magazine articles,* excited marked attention and did much to stimulate inquiry into flower fertilization among other scientists, as well as to interest the general public by their novelty, charm and beauty. In that shape, however, they have never been fully appreciated, and we are merely following out the author's own intentions in bringing this scattered material together in permanent form.

No effort has been spared to make the book thoroughly comprehensive and in every way representative of the author's work in this branch of science, which was so peculiarly his own, everything of value, both in the way of information and illustration, that he ever contributed to the subject being embodied in the present volume. Care has been taken, too, to preserve the charm of his literary style, no alterations having been made in the text that were not rendered absolutely necessary in endeavoring to make a logical, harmonious whole of scattered articles. A little new matter has been added to certain chapters where the different members of a family showed such marked individuality

* Afterward reprinted in the same form.

that fuller treatment than that originally accorded seemed desirable.

The plan of the book is as follows: First, the history of the discovery of the method of flower fertilization is carefully traced, then the method is worked out and explained in the case of an abstract flower, and the modifications of the various flower organs, due to their adaptation to their insect visitors, by means of natural selection, pointed out. The remainder of the book consists of twenty-five concrete examples of different methods of cross-fertilization. These examples stand as types of the ordinary processes adopted by nature.

It is thought that no method of preventing self-fertilization and insuring the opposite result exists among our wild flora that has not its prototype in these pages. As Gibson himself says of the orchids: "Each new species affords its new surprise in its special modification in adaptation to its insect sponsors;" but the general method is based on one of the plans illustrated.

In addition to furnishing a complete exposition of the processes involved, the book will be found a guide to the habits and characteristics of many individual species, tables being appended giving all the data at present available for about two

hundred and sixty flowers. The matter tabulated gives such important points as family, common and botanical names, insect visitors, and where the flowers are highly developed, the method of preventing or limiting self-fertilization.

It is suggested that the book be treated after the manner now employed by the best teachers in dealing with the English classics; that is, that it shall be used primarily as a reader and that the composition work shall then be drawn from it. The objection heretofore to treating scientific books in this way has been their lack of literary merit, which made them too poor a basis for the study of English, which necessarily goes hand in hand with composition work. This objection removed, as it has been in the present case, the method is ideal. The teacher's edition of "Blossom Hosts and Insect Guests" renders such a course possible for the busiest teacher, providing composition outlines and all other necessary aids for doing satisfactory work with the least possible expenditure of time and labor.

Ruskin says: "The more I think of it, I find this conclusion more impressed upon me, that the greatest thing a human soul ever does in this world is to *see* something. . . . Hundreds of people can talk

for one who can think, but thousands can think for one who can see. To see clearly is poetry, prophecy and religion—all in one." No study that could be named offers such a reward to keen observation as this subject of the fertilization of flowers, for so little of the vast scientific territory that it covers has been explored that it is quite possible for any ordinarily faithful student to add something to the world's knowledge of the laws that govern it.

E. E. D.

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Let us then content ourselves no longer with being mere "botanists"—historians of structural facts. The flowers are not mere comely or curious vegetable creations, with colors, odors, petals, stamens, and innumerable technical attributes. The wonted insight alike of scientist, philosopher, theologian, and dreamer is now repudiated in the new revelation. Beauty is not "its own excuse for being," nor was fragrance ever "wasted on the desert air." The seer has at last heard and interpreted the voice in the wilderness. The flower is no longer a simple passive victim in the busy bee's sweet pillage, but rather a conscious being, with hopes, aspirations, and companionships. The insect is its counterpart. Its fragrance is but a perfumed whisper of welcome, its color is as the wooing blush and rosy lip, its portals are decked for his coming, and its sweet hospitalities humored to his tarrying, and as it finally speeds its parting affinity, it rests content that its life's consummation has been fulfilled.

William Hamilton Gibson.

The Discoveries of Four Great Botanists

In "the enchanted world of botany, where the flowers, for reasons of their own, strive to grow hourly more beautiful."—Sir Edwin Arnold.

Wonderful as are the revelations of the "old botany" regarding the exquisite structure of the flowers, they are as nothing compared with the marvels which the "new botany" has to reveal.

The "old botany" concerned itself with the flowers only after they were dead—that is, plucked from the stalk—and then, having analyzed or separated them into their parts, asked no further questions about them. The "new botany," on the contrary, concerns itself with the flowers as individuals, studies them in their haunts, and inquires into their habits of life and the purpose of their existence.

A parallel to these two methods of study is found in the ornithological field—the early ornithologists contenting themselves with shooting and dissecting their bird, and the later investigators studying it while on the wing or occupied with nesting duties.

The superiority, both in interest and value, of the knowledge of the living flower or the living bird over that of the dead specimen need not be demonstrated.

In order to appreciate fully the contrast between these widely dissimilar schools of inquiry, it is well to trace briefly the progress, step by step, from the consideration of the mere anatomical and physiological specimen of the seventeenth century botanist to the conscious blossom of to-day with its embodied hopes, aspirations, and welcome companionship.

Most of my readers are familiar with the general

construction of a flower, but in order to insure such comprehension, it is well, perhaps, to freshen our memory by reference to the accompanying diagram, Fig. 1, of an abstract flower, the various parts being indexed.

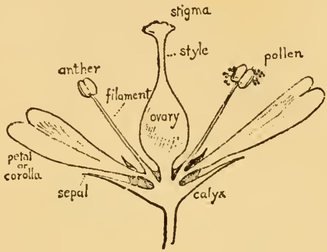

FIG. 1.

The calyx usually encloses the bud, and may be tubular or composed of separate leaves or sepals, as in a rose. The corolla, or colored portion, may consist of several petals, as in the rose, or of a single one, as in the morning-glory. At the centre is the pistil, or pistils, which form the ultimate fruit. The pistil is divided into three parts—ovary, style, and stigma. Surrounding the pistil are the stamens, few or many, the anther at the extremity containing the powdery pollen.

The botanists of a thousand years ago could have readily named these parts, but regarding their relation to each other, they could have told you nothing.

GREW EXPLAINS THE RELATION OF STAMENS AND PISTILS

The first observer to give to the world any information on this subject was Nehemias Grew, who announced in 1682 that it was necessary for the

pollen of a flower to reach the stigma or summit of the pistil in order to insure the fruit.

I have indicated his claim pictorially at A, Fig. 2, in the series of historical progression. So

FIG. 2.

radical was this "theory" considered that it precipitated a lively discussion among the wiseheads, which was prolonged for fifty years, and was only finally

settled by Linnæus, who reaffirmed the facts declared by Grew, and verified them by such absolute proof that no further doubts could be entertained. The inference of these early authorities regarding this process of fertilization or pollination of the stigma is perfectly clear from their statements. The stamens in most flowers were seen to surround the pistil, "and, of course, the presumption was that they naturally shed the pollen upon the stigma," as illustrated at B, Fig. 2 and in Fig. 3. The construction of most flowers certainly seems designed to fulfil, and frequently does fulfil, this end, but Nature does her best to prevent such an occurrence, favoring a very different process.

This theory might account, then, for the functions of the stamens and pistil; but what relation did color, fragrance, honey, and insect association bear to this problem of seed production? Had they anything to do with it, and if they had, what part did they play?

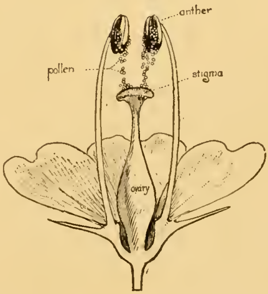

FIG. 3.

SOME EARLY SPECULATIONS

Some of the early speculations regarding these phenomena were very curious. Patrick Blair, for

instance, claimed that "honey," or, more properly, nectar, "absorbed the pollen," and thus fertilized the ovary. Pontidera thought that its office was to keep the ovary in a moist condition. Another botanist argued that it was "useless material thrown off in process of growth." Krunitz noted that "bee-visited meadows were most healthy," and his inference was that "honey was injurious to the flowers, and that bees were useful in carrying it off"! The great Linnæus confessed himself puzzled as to its function.

SPRENGEL MAKES KNOWN OTHER FLORAL SECRETS

For a period of fifty years the progress of interpretation was completely arrested. The flowers remained without a champion until 1787, when Sprengel began his investigations.

He labored on the work of interpretation for two or three years, and at length his researches were given to the world. In a volume bearing the victorious title, "The Secrets of Nature in Forms and Fertilization Discovered," he presented a vast chronicle of astonishing facts. The previous discoveries of Grew and Linnæus were right so far as they went—viz., the pollen must reach the stigma in order that the flower might produce seed, but those learned authorities had missed the true secret of the process.

Sprengel pointed out that in many flowers the stamens were far below the stigma, as shown in C, Fig. 2 and in Fig. 4. How, then, could the pollen reach the stigma? Clearly not in the manner suggested by Grew and Linnæus.

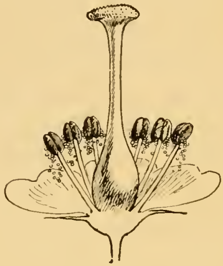

FIG. 4.

Sprengel partially solved this mystery. He cast a ray of light into the darkness, but it was not strong enough to reveal the whole truth.

He announced the startling theory that:

I. Flowers, which, from their structure, are unable to fertilize themselves, are fertilized by insects.

II. That all such flowers contain nectar, which is food for insects, and that, in obtaining this food, the insects brush the pollen from the anthers with the hairy parts of their bodies. As they fly away, they necessarily come in contact with the stigma, which scrapes off the pollen they have just collected and is thus fertilized. D, Fig. 2, represents the process suggested.

This theory, he claimed, would explain also the presence of color and fragrance*—both of these attributes serving to attract insects, the color also

* No sooner was this fact asserted than it was urged that certain flowers, which Sprengel afterward called "*Shein saft blumen*," or sham-nectar producers, of which the *Orchis morio* is a good

pointing the way to the nectar*—the spots, rings, and converging lines on the petals constituting so many guide-posts on the road to the nectary.

THE WEAK POINTS IN SPRENGEL'S THEORY

Why was Sprengel's seeming victory an empty one? All that he stated about nectar, fragrance, and color is true. These floral attributes are the result of adaptation to insects, and have been acquired for the special purpose of attracting them. His theory fitted perfectly, too, the problem shown in C, Fig. 2 and in Fig. 4. An insect could without doubt fertilize such a flower with its own pollen, but Sprengel's carefully noted facts showed only too plainly that there were many other flowers incapable of fertilizing themselves, and yet quite as incapable of being fertilized in the way he had described.

For instance, he was met at every hand by floral problems, such as are shown at E and F, Fig. 2,

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example, possessed perfect nectar guides, and yet produced no nectar. Sprengel supposed that these plants existed by an organized system of deception, by leading the insects to suppose that nectar was concealed in their depths, and thus inducing them to enter and perform the service of the transfer of pollen, and then cheating them of their reward. Darwin, however, showed that the nectar in *Orchis morio* was contained in the upper and lower tissues of the corolla; he also explained the reason for this concealment. (See page 27.) Many flowers produce quantities of pollen and little or no nectar. Such flowers are especially adapted to pollen-gathering insects.

*Evil-smelling flowers, like the trillium, attract carrion-loving flies—the vile odor of these blossoms being the result of adaptation to this special class of insects.

A HONEY-DEW PICNIC

where the pollen ripens before the stigma matures. In many cases, too, the pollen-bearing stamens are all in one flower, while the pistils are in others, as in the cucumber and Indian corn, and in some instances, as in the palms and willows, on different plants. A purely mechanical method of preventing self-fertilization is shown in Fig. 5. These phenomena are, however, all of one class. When the method of fertilization in one case is understood, it may be applied to all.

FIG. 5.

Under the conditions presented at E and F, if the insect did deposit the flower's pollen on its own stigma, the pollen would fail in its mission, since the stigma would not yet have reached the point where it could make use of the gift. The reverse problem also faced him, the pollen often being retained within the anthers until the stigma withers. In spite of these facts, he saw that this class of flowers continued to exist and to produce seed, but their method of doing it steadily eluded him.

In addition to this weakness in Sprengel's theory, there was yet another defect. Sprengel could give no reason why insect fertilization was more desirable than self-fertilization. Why should the flowers be

at such pains to attract the insects when by a different arrangement of their internal economy they might, as other blossoms frequently do, fertilize themselves?

"Let us not underrate the value of a fact; it will one day flower in a truth." The defects in Sprengel's work were, after all, not actual defects. The error lay simply in his interpretation of the facts which he had been at such pains to gather.

He and his followers heard faint whisperings of the truth which would have solved all difficulties. But they heard whisperings only—they never realized the whole of the deep-laid plan.

DARWIN'S REVELATIONS

It was not until the inspired insight of Darwin, as voiced in his "Origin of Species," contemplated these strange facts and inconsistencies of Sprengel that their full significance and actual value were discovered and demonstrated, and his remarkable book, forgotten for seventy years, at last appreciated for its true worth. Alas for the irony of fate! Under Darwin's interpretation, the very "defects" which had rendered Sprengel's work a failure became the absolute witness of a deeper truth which Sprengel had failed to discern.

One more short step and he would have reached

the goal. But this last step was reserved for the later seer.

Darwin took the double problem of Sprengel, as shown at E and F, Fig. 2, and by the simple drawing of a line, as it were, as in G and H, instantly reconciled all the previous perplexities and inconsistencies, thus demonstrating the fundamental plan involved in floral construction to be not merely "insect fertilization" of the individual flower, the fatal postulate assumed by Sprengel, but "cross-fertilization" by insects,* the carrying of the pollen from flower to flower, either of the same plant or of different plants—a fact which, singularly enough, Sprengel's own pages proved, but which he only dimly suspected. Fig. 6 shows the same condition as represented by G and H, Fig. 2.

While the stigma of G is immature and cannot avail itself of the pollen in its own flower, the stigma of H is fully developed, while its pollen-bearing anthers have withered.

An insect—let us say Bombus—however, can readily remedy this difficulty. Crawling into the nectary of G, he gets himself well powdered with its pollen, which he forthwith carries to the stigma of

* Insects are by no means the only agents which nature employs in this work of pollen transfer—birds, wind, and water also assist in the work; but it is with insects as the chief agents that this book is concerned.

H, and thus fertilizes it. Doubtless he will do the same for the stigma of G when it matures.

Not only did Darwin's theory solve the first mystery which Sprengel left unexplained, but it was equally successful in untangling the second knot.

No reason could be given why fertilization by insects, according to the theory of Sprengel, was

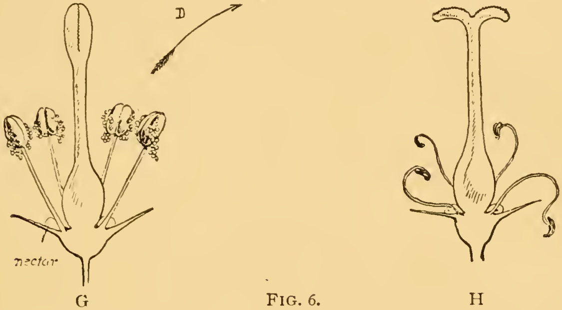


FIG. 6.

preferable to self-fertilization; but, as Darwin soon proved by actual experiment, cross-fertilization is a distinct advantage to the flower, in the competitive struggle for existence, all cross-fertilized flowers producing healthier seed than self-fertilized ones. Cross-fertilized flowers, therefore, are the final result of natural selection, or the law of the survival of the fittest.

HOW NATURAL SELECTION PERFECTS THE FLOWERS

To illustrate how this law has worked in the development of cross-fertilized flowers, let us suppose,

what has, without doubt, actually been the case, that the early ancestors of a certain flower were self-fertilized. At length, among other continual variations,* certain seedlings showed the singular variation of ripening their pollen in advance of their stigmas or in other ways developed peculiarities which prevented self-fertilization. At the same time that they began to develop this condition, the flowers began to secrete nectar in their cups. A passing insect, lured by the sweets, entered a blossom, and while sipping its honey dew became dusted with its pollen, which he deposited on the stigma of the next flower he visited.†

The flower thus fertilized acquired a strain of fresh vigor. Its seedlings coming now into competition with the existing weaker self-fertilized forms, by the increased vigor won in the struggle of their immediate surroundings, and inheriting the peculiarity of their parents, showed flowers possessing the same cross-fertilizing device. The seeds from these again scattering continued the unequal struggle in a larger and larger field, and in increasing

* It is this tendency to variation in individual flowers that makes it possible for nature to select and preserve traits and peculiarities which are of value to the plant.

† The fulfilment of these conditions implies, of course, flowers in various stages of development—some with ripe anthers and immature stigmas, and some with mature stigmas and withered anthers.

numbers, continually crowding out all their less vigorous self-fertilized competitors of the same species, at length to become entire masters of the field and the only representatives left to perpetuate the line of descent.

Everything in nature is in a state of change or evolution, and we can find flowers of all degrees in the scale of cross-fertilization, from those at a low stage of development, adapted to insects as a whole, but not to any special class, and often retaining, as a last resort, the power of self-fertilization, to those which, like the orchid, can be fertilized only by a single species of insect, and actually perish if it fails to visit them.

The question here arises, are there any flowers that are invariably self-fertilized? There are a few.

CLEISTOGAMOUS BUDS

A good example of such a flower is found in the violet, which produces two distinct blossoms on the same plant, one a little blind or "cleistogamous" flower, which grows close to the ground and which is always self-fertilized, and the other the showy blossom, with which we are all familiar, this latter blossom being formed for cross-fertilization.

The blind flower is rarely seen, as it is a tiny

pointed affair, which never even peeps beyond its calyx. Unpretentious as it seems, it produces a pod that is literally packed with seeds. It matures in the late summer and autumn.

These seed packets are among the finest sharpshooters of the autumn woods, often pinching out their pear-shaped seeds a distance of ten feet upon the dried leaves.

THE VIOLET'S BLIND FLOWER

Cleistogamous flowers are an economical provision, as they produce many seeds at small cost to the plant. They doubtless prove of great value, too, where there are few insects or where other conditions exist unfavorable to frequent cross-fertilization.

The ginseng, the polygala, and some other plants hide their cleistogamous flowers below ground. The fact that these self-fertilized flowers are always found on plants bearing also cross-fertilized blossoms goes to prove that Nature never leaves a

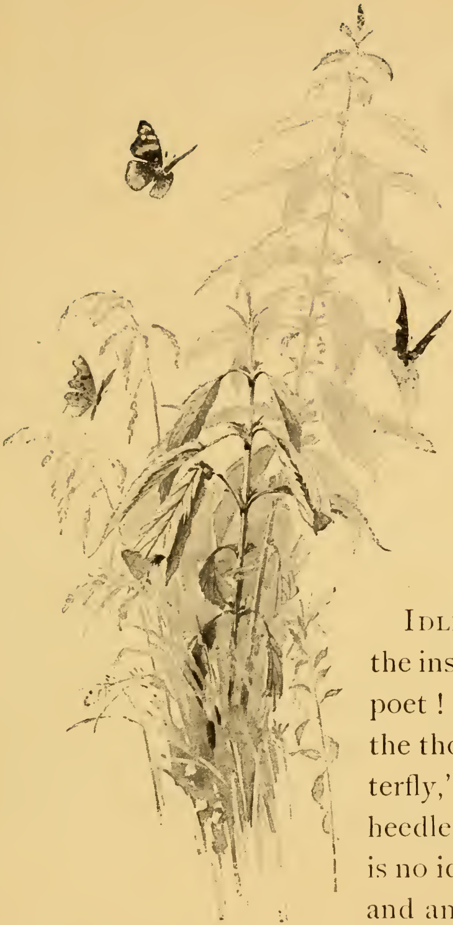
flowering plant * wholly dependent for the propagation of its kind upon seeds produced by the self-fertilized method, providing, if need be, two varying

AUTUMN SHARP-SHOOTER

blossoms on the same plant in order to insure the production ot some seed by the cross-fertilized process.

* These terms, flowering and non-flowering plants, used throughout this explanation are not strictly correct, but answer all practical purposes. In this volume we are dealing exclusively with flowering plants which form only one part of the vegetable kingdom. Any explanation regarding seeds or spores produced by asexual union in ferns, mosses, etc., would lead us into the realm of non-flowering plants—another great division of the plant world.

Darwin states it as his belief that none of the higher forms of plant life (flowering plants) can fertilize itself for a number of successive generations. It must be crossed with another individual occasionally, preferably one on a different plant, and the more frequently this crossing of races occurs the better it is for the plant.



How the Flowers Woo the Insects

"Gold-barred butterflies,
  to and fro,
 And over the waterside
  wandered and wove,
 As heedless and idle as
  clouds that rove
 And drift by the peaks
  of perpetual snow."

Idle indeed! Observe the insect more carefully, my poet! We have cherished the thought of the "idle butterfly," the type of charming heedlessness, too long. He is no idler, but a hard worker and an earnest student, who could tell the wisest of us, if he would speak, more true science than we have ever dreamed of.

It was the constant presence of these "idlers" at the blossoms' throats that led Sprengel and Darwin

to that close study of the flowers which resulted in our present knowledge of the method by which they perpetuate themselves. This is a wonderful scientific truth; but the butterfly whispers that there is more to learn, that there always will be more to learn.

The flower of to-day! What an inspiration to our reverential study! What a new revelation is borne upon its perfume! Its forms and hues, what invitations to our devotion! This spot upon the petal; this peculiar quality of perfume or odor; this fringe within the throat;* this stamen and pistil, so close that they almost touch, and yet so widely separated! What a catechism to one who knows that each and all represent an affinity to some insect —a long-tongued night moth, perhaps, with whose life its own is mysteriously linked through the sweet bond of perfume and nectar and the sole hope of posterity.

Having found, as it were, our marvellous cross-fertilized flowers, let us enter any woodland path and, plucking a few blossoms, examine them more closely, for we have by no means fathomed all the mysteries of their adaptation to insects, or even guessed to what extent it may be carried, or the

* The fringe protects the nectar from rain.

reasons that underlie the varying structure of the different organs.

NECTARY RIDDLES

Here, for instance, are two flowers—one with a long and narrow nectary, and the other with a

A WOODLAND PATH

broad and shallow one. The coloring, too, differs greatly. What is the explanation of these variations? Simply that at some point in their life history each of these flowers made a compact with a different tribe of insects, to which it has ever since been adapting itself.

At the time they were both, probably, at a low stage of development, visited by many insects, but adapted to no special class. They doubtless entertained vagrants such as we see to-day wandering from flower to flower,

"Kissing all buds that are pretty and sweet."

This proved a poor method for both flowers and insects. The insects might visit blossom after blossom, only to find that the nectaries had been drained by previous guests; and the flowers, since they had no special attraction to offer over any other flowers, constantly ran the risk of being passed by and left to wither, their mission in life unfulfilled or accomplished only by the unsatisfactory process of self-fertilization.

So it came about that one day the flower that we now see with the long nectary made a compact with Mistress Butterfly. It agreed to hide its nectar in a deep, narrow pocket where Master Bombus could not possibly thrust his great head. The flower which has the shallow nectary, on the other hand, came to an agreement with Master Bombus to broaden its nectar pocket for his special benefit.

How is the flower designed for Master Bombus protected from the raids of Mistress Butterfly, say

you? Possibly its blue* dress, which so charms the busy bee, is distasteful to her, or its honey not seasoned to her dainty palate.

It is not always necessary for a flower to protect its sweets. It is enough that it should be attractive to the insect it favors. Each class of insects having special races of flowers catering to its needs speedily learns where it is most welcome and most certain of entertainment.

Nearly all flowers, however, protect themselves from creeping pilferers. Common methods of doing this are by exuding a sticky substance along their stems, or covering them with a fuzzy growth. The closed gentian keeps its petals always folded for this reason.

In return for the attractions or protection offered by their special friends, the Butterfly and the Bee agreed to be faithful to their affinities and work diligently for them in the transfer of their pollen.†

FLOWERS AND INSECTS SUBJECT TO THE SAME LAW

Years or decades do not count in the process of

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*Lubbock's careful experiments would seem to prove that bees prefer blue flowers, moths white, butterflies various shades of red, and beetles and small flies white and yellow. White and pale yellow, being more conspicuous in the dark than any other color, have been almost universally adopted by night-blooming flowers.

†Another reason which tends to make an insect remain true to a certain species while in bloom is the fact that it can work much more rapidly by so doing, as it knows the method of approach thoroughly

evolution. It has probably taken centuries for each of these nectaries to become perfectly suited to the particular insect for which it was designed, but through natural selection, each century has added something to the depth of the one nectary and the breadth of the other.

It is through this law, as you remember, that the cross-fertilized flowers displace the self-fertilized ones, and in the same way the flowers that most readily adapt themselves to their insect friends survive and push aside their less well-developed fellows.

The insect, too, so soon as the flower begins to adapt itself especially to him, must in turn adapt himself to it. If Mistress Butterfly's tongue is too short to reach to the bottom of the flower's nectary, or if Master Bombus's head does not fit the pocket prepared for him, they both fail to obtain their food, and may possibly die of starvation.*

It is often said that the laws of Flora's kingdom,

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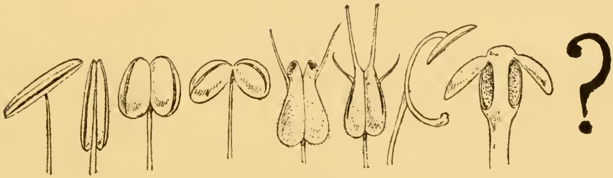
and the flowers are apt to be close together. The industry of these little creatures is amazing. Bees have been known to visit twenty flowers a minute, and individual blossoms are frequently visited as many as thirty times a day. Nectar is generally secreted by a flower until pollination is effected, or, until the hope of this end being abandoned, the flower withers. This gives a blossom many more opportunities for cross-fertilization than if its nectar was exhausted by one visitor.

* This is true only in a limited degree. It is a great advantage to the insect to adapt himself to the flowers he feeds on, but he is not so absolutely dependent upon an individual species of flower as the species often is upon him.

which thus crush the weak and protect the strong, are more just than merciful. It is true that any breach of contract between flower and insect, especially if it is persisted in, is frequently punished with death to the offending one; but this is the extreme penalty, which is often modified, as we shall learn.

STAMEN AND PISTIL LESSONS

The stamens as well as the nectary have a lesson to teach. The function of the stamens, as you know, is the secretion of pollen. This function, however,



STAMENS

has no reference whatever to the external form of the stamen. Why, then, do we find such remarkable divergence as is here pictured? Another instance of adaptation to an insect? Yes. But the reason for this adaptation is somewhat different from that which caused the nectaries to vary.

The stamens differ in order to insure the transfer of their pollen. The variety of methods employed by flowers in loading their insect messengers with pollen is beyond belief. Each method requires

different stamen machinery, hence their varying structure.

Where moths and butterflies are the flowers' sponsors, the stamens are generally so arranged that the pollen can be deposited on the visitor's eyes or tongue; where a bee is the ally, the stamens are apt to be placed so as to come in contact with his back, head, sides, legs, or thorax.

The methods are infinite in number; there are

VARYING FLOWER ORGANS

exploding flowers, flower traps, stamen embraces, pollen showers, pollen plasters, and pollen necklaces. Darwin discovered that the pollen of *Orchis morio*, whose apparent lack of nectar so puzzled Sprengel, must be actually glued to the insect in order to insure its safety. The flower, therefore, requires the insect to bore through an outer skin to reach his food. While he is thus employed, the pollen is securely fastened to him.

Pistils are no exception to the rule; they, as well as every other organ, must be modified to suit the flower's affinity. They must be formed so as to secure and retain the pollen gifts brought to their stigmas. The variations are not so great as among the stamens, but, nevertheless, there is wonderful diversity.

The flower is even placed on its stalk in a position convenient for the insect's entrance.

With Darwin as our guide, then, and the insect as our key—an open sesame—the hidden treasure is revealed. It is now quite possible, as Darwin demonstrated, to look upon a flower for the first time and from its structure foretell the method of its intended cross-fertilization—nay, more, possibly the kind or even the species of insect to which this cross-fertilization is entrusted.

THE GREAT ANGRÆCUM

A remarkable instance of the adaptation of a flower to a single species of insect is seen in the great Angræcum orchid of Madagascar, described by Darwin. This species glorifies Darwin's faith in the truth of his theory, and marks a notable victory in the long battle for its supremacy.

Among the host of sceptics who met his evolutionary and revolutionary theory with incredulity, not to say ridicule or worse, was one who thus challenged him shortly after the appearance of his "Fertilization of Orchids," addressing him from Madagascar substantially as follows: "Upon your theory of evolution through natural selection all the various contrasting structural features of the orchids have direct reference to some insect which shall best cross-fertilize them. If an orchid has a nectary one inch long, an insect's tongue of equivalent length is implied; a nectary six inches in length likewise implies a tongue six inches long. What have you to say in regard to an orchid which flourishes here in Madagascar possessing a long nectary as slender as a knitting-needle and eleven inches in length? On your hypothesis there must be a moth with a tongue eleven inches long, or this nectary would never have been elaborated."

Darwin's reply was magnificent in its proof of the sublime conviction of the truth of his belief: "The existence of an orchid with a slender nectary eleven inches in length, and with nectar secreted at its tip, is a conclusive demonstration of the existence of a moth with a tongue eleven inches in length, *even though no such moth is known.*"

Some of us remember the ridicule which was heaped upon him for this apparently blind adherence to an untenable theory. But victory complete and demoralizing to his opponents awaited this oracular utterance when later a disciple of Darwin, led by the same spirit of faith and conviction, visited Madagascar, and was soon able to affirm that he had caught the moth, a huge sphinx-moth, and that its tongue measured eleven inches in length.

Here we see the prophecy of the existence of an unknown moth, founded on the form of a blossom. At that time the moth had not been actually seen at work on the orchid, but who shall question for a moment that had the flower been visited in its twilight or moonlight haunt the murmur of humming wings about the blossom's throat would have attested the presence of the flower's affinity; for without the kiss of this identical moth the Angræcum must become extinct. No other moth can fulfil the

conditions necessary to its perpetuation. The floral adaptation is such that the moth must force its large head far into the opening of the blossom in order to reach the sweets in the long nectary. In so doing the pollen becomes attached to the base of the tongue, and is withdrawn as the insect leaves the flower, and is thrust against the stigma in the next blossom visited. This was clearly demonstrated by Darwin in specimens sent to him, by means of a probe of the presumable length and diameter of the moth's tongue. Shorter-tongued moths would fail to remove the pollen, and also to reach the nectar, and would thus soon cease to visit the blossom.

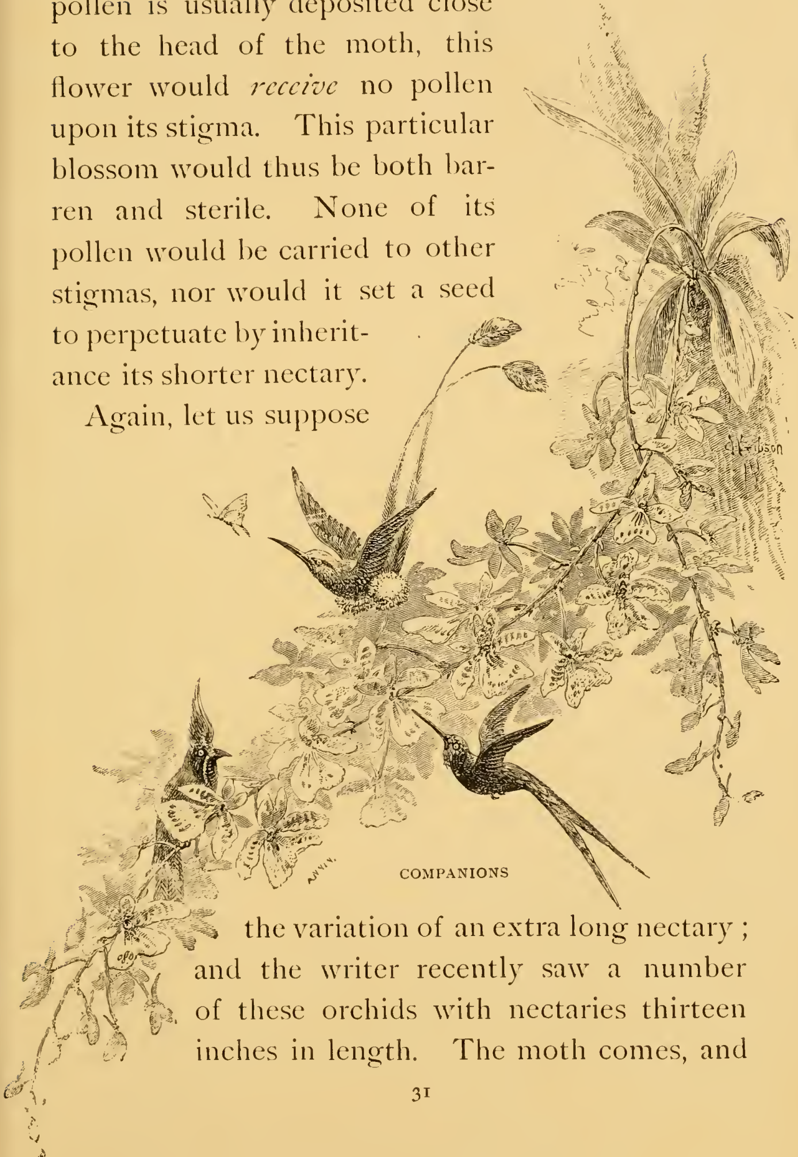
HOW NATURAL SELECTION PERFECTS THE ANGRÆCUM

The Angræcum also affords in this long pendent nectary a most lucid illustration of the present workings of natural selection. The normal length of that nectary should be about eleven inches, but, in fact, this length varies considerably in the flowers of different plants.

Let us suppose a flower whose nectary chances to be only six inches in length. The moth visits this flower, but the tip of its tongue reaches the nectar long before it can bring its head into the opening of the tube. This being a vital condition, the moth fails to withdraw the pollen; and inasmuch as the

pollen is usually deposited close to the head of the moth, this flower would *receive* no pollen upon its stigma. This particular blossom would thus be both barren and sterile. None of its pollen would be carried to other stigmas, nor would it set a seed to perpetuate by inheritance its shorter nectary.

Again, let us suppose



COMPANIONS

the variation of an extra long nectary; and the writer recently saw a number of these orchids with nectaries thirteen inches in length. The moth comes, and

now must needs insert its head to the utmost into the opening of the flower. This would insure its fertilization by the pollen on the insect's tongue; and even though the sipper *failed* to reach the nectar, the pollen would be withdrawn upon the tongue, to be carried to other flowers, which might thus be expected to inherit from the paternal side the tendency to the *longer* nectary. The tendency toward the perpetuation of the short nectary is therefore stopped, while that of the longer nectary is insured.

The Angræcum is only one of a family of plants numbering some thousands of known species, and yet nearly all of them would be doomed to extinction were it not for their legion of insect, butterfly and humming-bird friends and companions.

NATURE'S TOLERANCE

Because of the law of the "survival of the fittest," Dame Nature has gained the reputation of being cruel; but when you have studied her ways closely, you will find that she is really very tolerant. She does not approve of close or self-fertilization, yet often permits plants to retain this power as a last resort, as in the case of the dandelion. If insects fail to fertilize this blossom, it gradually separates and curls back on its stem, thus bringing the inside

—stigmatic—surface in contact with the outside—pollen-bearing—surface. Fertilized in this way, it is possible for the flower to produce seed without the aid of insects.

Progress is Nature's law. So long as the flowers are improving, Nature will tolerate them. She gives them many opportunities to prove their fitness to live by showing that they are of use in this busy world, where there is so much to be done. But woe to the flower or insect that, in spite of all the aids that Nature may extend, continues to degenerate. Death will surely be the penalty eventually meted out to it.

In the case of the Angræcum and its companion moth, we cannot doubt that tolerance is shown. Of course, in the extreme example cited, where the blossom is so defective as to lack five inches of the normal length, its chances of setting seed are very few; but even in this case, conditions may possibly arise which will enable it to mature its fruit.

Where a blossom falls only a little short of the requirements, it is permitted many opportunities for fertilization. For instance, the moth, whose tongue is too short to sip the honey of the flower with the thirteen-inch nectary, may, after receiving its pollen, pass on, in his search for food, to a blossom with a

ten-inch nectary, and there gratify his appetite, and at the same time assist the defective flower in accomplishing its mission in life. This particular blossom, having now been crossed with a flower whose nectary was unusually long, its seed will probably produce blossoms of the average length.

Our knowledge of the workings of natural selection is too limited for us to lay down hard and fast rules regarding it. All that we can say is that the tendencies are in certain directions. Natural selection works only on the broadest lines and over long periods of time.

NATURE'S FRUGALITY

It is quite possible that in many of the variations we note, we see the beginning of a new species. To put it concretely, if the Angræcum produced many blossoms with six-inch nectaries, they might serve to feed some species of moth with a tongue of that length, which, in return, would transfer their pollen. Should this be true, Nature, in all probability, would begin to adapt them to each other. It would be wasteful to destroy, or rather eliminate, any plant life that was worthy to exist; and Nature is always frugal.

In all this complicated flower machinery, we find nothing unnecessary. If fragrance is a sufficient

attraction to insure its perpetuation, the construction of the flower is most simple ; if color is sufficient, all effort at adaptation ceases there. If a goodly store of pollen suffices to attract the insect sought and nectar is not required, all the efforts of the flower are expended on the manufacture of pollen, and no nectar is secreted. When the end in view is insured, Nature's work is finished in that particular direction. It is therefore quite usual to find plain, unattractive flowers that are more complicated in their internal mechanism than the beautiful rose or flaming peony.

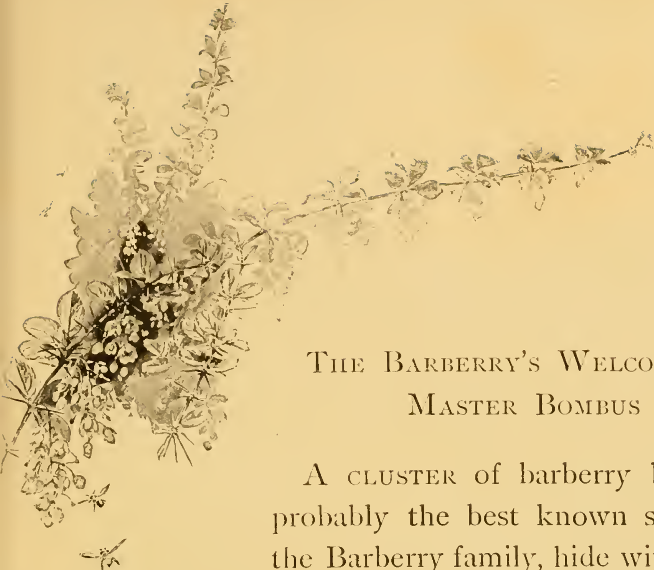
The orchids, that rare race, need every attraction and the most tender care that Nature can bestow to insure their continued existence, and are therefore among our most exquisitely fashioned, as well as most wonderfully beautiful flowers.

Look where we will among the blossoms, we find the same beautiful plan of intercommunion and reciprocity everywhere demonstrated. The means appear without limit in their evolved—rather I should say, involved ingenuity.

While each family of plants is apt to favor some particular general plan in their adaptation to insects, the modifications in the various species seem almost without limit. Pluck the first flower that you meet

in your stroll to-morrow and it will tell you a new story—in some cases a beautiful story of perfect adaptation,* in others an unfinished story, but in very instance an interesting story.

* Perfection of every part is never attained in the vegetable any more than in the animal kingdom. There is always room for improvement in some way.



The Barberry's Welcome to Master Bombus

A cluster of barberry blossoms, probably the best known species of the Barberry family, hide within their yellow cups a secret well worth learning.

Poets of all ages have loved to dwell upon the flowers—their "swete smels," exquisite forms, fragrance, and colors. The droning bees in an environment of fragrant bloom have moved many a poetic pen to inspiration. But it is not often that the bards have seen deep enough into the floral mysteries to immortalize the *doings* of the blossoms.

I recall one such allusion, however, with reference to this mischievous blossom of the barberry. How well Hosea Biglow knew its pranks!

> "All down the loose-walled lanes in archin' bowers
> The barb'ry droops its strings o' golden flowers,
> Whose shrinkin' hearts the school-gals love to try
> With *pins*. They'll worry yourn so, boys, bime-by."

Those "shrinkin' hearts" of the barberry blossom, so long the wonder and amusement of children, including many children of adult growth, have, so far as I know, herein found their first and only historian—historian, but not interpreter; for neither Hosea Biglow nor his literary parent, James Russell Lowell, ever dreamed of the significance of this strange spectacle in the "shrinkin' hearts" of the barberry bloom when surprised with a point of a pin.

But the bee can tell us all about it. He has known this singular trick in the barberry for ages, and kept the secret all to himself. It is his visits in May and June to the "shrinkin' hearts" of the golden flowers that produce the clusters of brilliant scarlet acid berries of September, as we shall presently see.

At Fig. 1 I have shown a plan of the barberry blossom seen from below, its yellow sepals and petals open, and opposite each of the inner set, and pressed against it, a stamen. This stamen is shown below in three stages—closed, partly open, and fully open—the queer little ear-shaped lids finally drawn up, showing the pollen-pockets, and also withdrawing a portion of the pollen from the cavity. At the center is seen the circular tip of

"In archin' bowers"

the ovary, which finally becomes the berry—that is, when the little scheme here planned has been fulfilled. This circular form represents the tip of the ovary, and the little toothed rim the *stigma*. Now, what is the intention here expressed? This construction represents a plan, first, to invite a bee. This is done, as in all flowers visited by insects, by its color, its fragrance, and its nectar, which is secreted in a gland at the base of each petal, near the centre of the flower; secondly, to make that

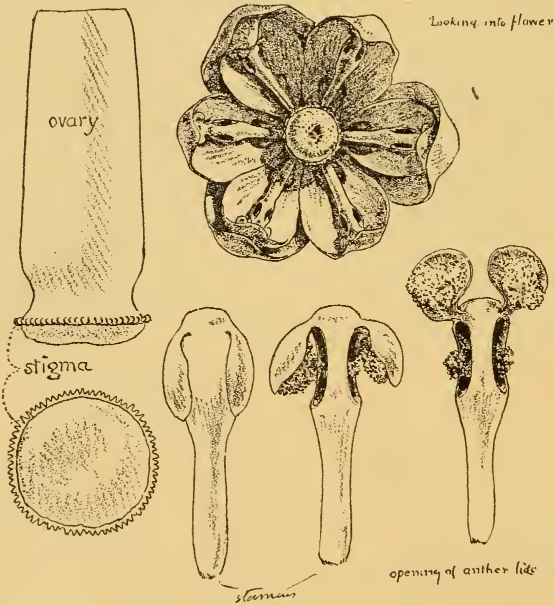
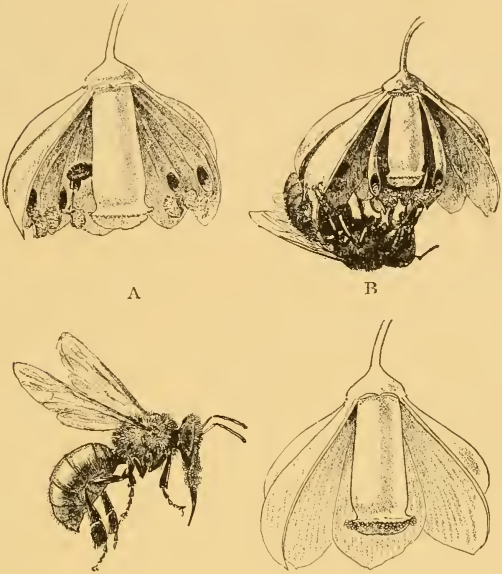


FIG. 1.



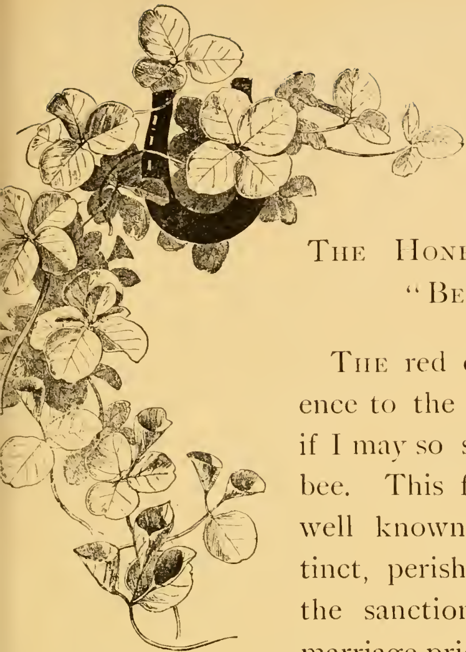
A B

C

FIG. 2.

bee bear away the pollen; thirdly, to cause that same bee to place this pollen on the stigma rim of the next flower he visits. In Fig. 2 we see how beautifully this plan is carried out by the insect. At A we see the same flower cut open sideways, the waiting, expectant stamens tucked away at the sides, leaving a free opening to the base of the flower. Now comes our bee. He must needs hang back downward to sip at the drooping flower. As his tongue enters, and finally touches the base

of these stamens, *clap!* they come one after another against his tongue and face, and there deposit their load of pollen (B). The bee, who has doubtless got over his surprise at this demonstration—if, indeed, he ever had any—now flies to another blossom, perhaps on the same cluster (C). Entering it as before, the notched edge of the stigmatic rim comes in contact with the pollen on his tongue and face, and the flower is thus fertilized by pollen from another barberry blossom, the intention of the flower now perfectly realized in cross-fertilization.



The Honeyed Clover—The "Beggar's Tick"

The red clover owes its existence to the "epicurean of June," if I may so speak of the bumblebee. This fastidious plant, it is well known, would become extinct, perish in celibacy, without the sanction of this busy little marriage-priest.

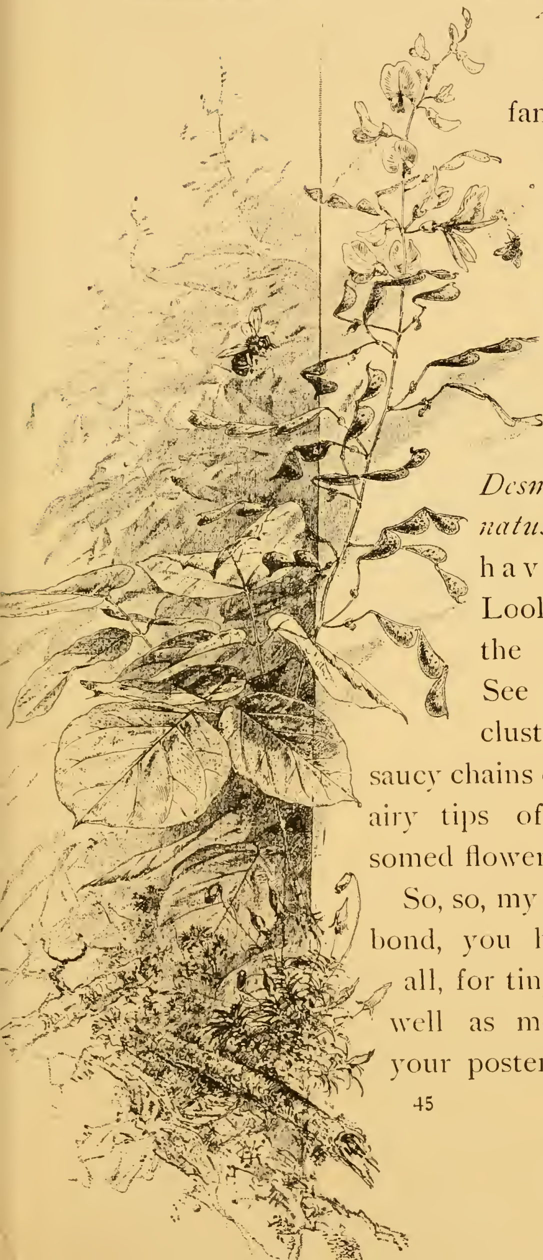
Like many other members of the Pulse family, it has what would seem to us a rude welcome for its guests. A shot-gun lies in wait for them loaded to the muzzle with pollen powder, and with the trigger carefully set, so that they cannot fail to press it while searching for sweets.

In an endeavor to establish a clover crop in Australia, it was discovered that while the first sowed growth from imported seed thrived luxuriantly, it ripened no seed, and thus defeated its self-perpetuance; and all because Bombus was not

consulted. The importation of a few shiploads of bumblebees, however, insured an abundant crop. Thus, when this "breezy hum" of the Bombus is heard no more in our meadows, we must say good-by to the red clover.

And now, apropos of such an extremity, I am reminded of that remark of Darwin, who traces back a little farther to the source of our obligation. Clover, he reasons, depends upon the number of cats. No cats, no clover. Clover will not produce seed unless its flowers are fertilized by bumblebees; the nests of the bees are eagerly destroyed by mice; cats kill the mice—thus the bees are spared, and having these, the clover is insured. Very good! "Cats and clover" as a context may be more alliterative, but most of us who are at all given to sentiment will welcome the interposing links in the chain of cause and effect.

By what endless devices does Nature thus secure her ends! The design beneath the construction of *any* flower we may pluck—often the very commonest by the roadside—is a profound riddle, often unanswerable until we await the oracle of its chosen mouthpiece, perhaps the one confidant for whom it has been adapting and shaping itself through the ages.



AN INTERESTING VAGABOND

Here is another familiar face. We all know him—the tramp of the underwoods; for who, in spite of himself, has not brought home the "beggar's ticks"? *Desmodium accuminatus* the records have him down. Look out for him in the rogue's gallery. See him now! with clustered leaves and saucy chains of seed-pods and airy tips of pink pea-blossomed flowers!

So, so, my impetuous vagabond, you have a slap for all, for tiny bee and fly as well as me. You secure your posterity by the same

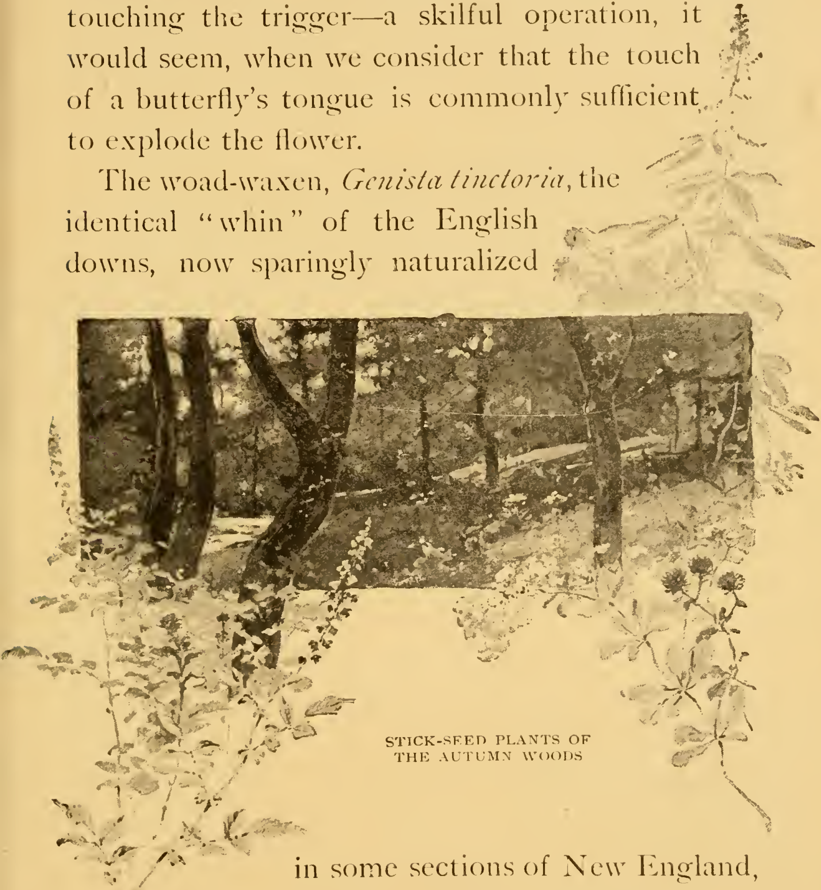
aggressive arts with which you perpetuate their vagrancy. A little fly alights upon the small pink blossom, when, lo! the flower explodes, the insect is greeted with a slap on the face or breast, and a dab of dust in his eyes. For this flower, too, is a veritable trap, delicately set. Upon the slightest touch, the loaded spring—consisting of the rigid column of filaments enclosing the young pod—is released from the overlapping petals, and the anthers hurl their shower of pollen upon the body of the intruder. But observe the wise adjustment beneath all this mechanism. The stigma—the organ through which the seeds are fertilized—projects a little beyond the anthers, and is the first to come in contact with the insect, and thus gets a supply of pollen from the previously visited flower.

It is the pollen-collecting bees which the Beggar's Tick wishes to attract. The plant, therefore, has directed its energies, through the ages, to increasing its store of golden powder rather than to laying up sweets, its food being intended for unborn generations, not for the insect that does its bidding.

In the lucerne, *Medicago sativa*, the flowers are similarly explosive, and it has been observed that bees find this continual belaboring unpleasant, and

contrive means of obtaining their nectar without touching the trigger—a skilful operation, it would seem, when we consider that the touch of a butterfly's tongue is commonly sufficient to explode the flower.

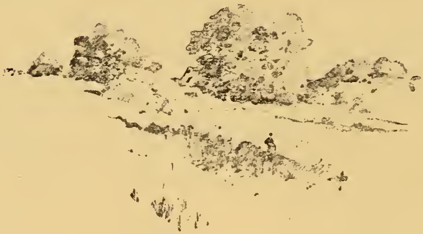
The woad-waxen, *Genista tinctoria*, the identical "whin" of the English downs, now sparingly naturalized



STICK-SEED PLANTS OF THE AUTUMN WOODS

in some sections of New England, affords, perhaps, in the large size of its flowers and rigid tension, the best illustration of this peculiar explosive mechanism to be found among our flora, and, like the various

desmodiums, is well worth a little study in its haunts. The two forms of the flower, both before and after explosion, are easily observed upon almost any single plant.



The Evening Primrose and the Hovering Moth

The summer which is allowed to pass without a visit to the twilight haunt of the evening primrose, perhaps at your very door, is an opportunity missed.

Night after night for weeks this beautiful member of the Primrose family breathes its fragrant invitation as its luminous blooms flash out one by one from the clusters of buds in the gloom,

as though in eager response to the touch of some wandering sprite, until the darkness is lit up with their luminous galaxy—that beautiful episode of blossom consciousness and hope so picturesquely described by Keats.

> "A tuft of evening primroses
> O'er which the wind may hover till it dozes,
> O'er which it well might take a pleasant sleep,
> But that 'tis ever startled by the leap
> Of buds into ripe flowers."

Nor is it necessary to brave the night air to witness this sudden transformation. A cluster of the flowers placed in a vase beneath an evening lamp will reveal the episode, though robbed of the poetic attribute of their natural sombre environment and the murmuring response of the twilight moth, a companion to which its form, its color, and its breath of perfume and impulsive greeting are but the expression of a beautiful divine affinity.

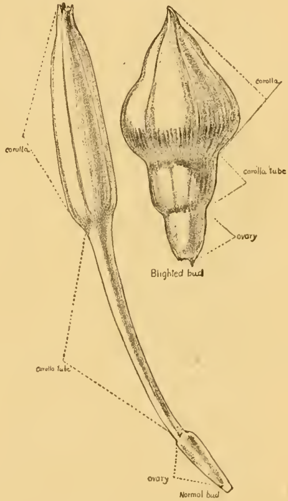
The primrose presents the peculiar phenomena of two kinds of buds, as shown in the accompanying drawing.

Regarding these varying buds, I once received the following letter:

"I read in 'Harper's Young People' your piece about the evening primrose, and found the little moth and the catterpilers, what I never seen before;

but they is one thing what you never tole us about yit. Why is it that the buds on so meny evening primroses swell up so big and never open? Some of them has holes into them, but I never seen nothing cum out."

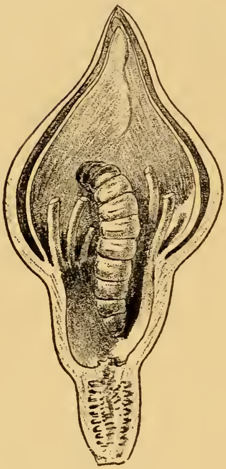
This same question must have been mentally propounded by many observers who have noted this singular peculiarity of the buds—two sorts of buds, one of them long and slender, and with a longer tube; the other short and stout, with no tube at all—both of which are shown in proper proportion in my illustration. It is well to contrast their outward form, and to note wherein they differ. In the normal or longer bud the tube is slender, and extended to a length of an inch or more, while in the shorter specimen this portion is reduced to about a fifth or a sixth of that length, while the corolla enclosed within its sepals is much shortened and swollen.



The difference in the shape and development of

these two buds is a most interesting study, as bearing upon the conscious intention of the flower as an embodiment of a divine companion to an insect. What is the intention involved in the construction and habit of this flower?

What are we to infer from the shape of our evening primrose? Its tube is long and slender, and the nectar is secreted at its farthest extremity. Only a tongue an inch or so in length could reach it. What insects have tongues of this length? Moths and butterflies. The primrose blooms at night, when butterflies are asleep, and is thus clearly adapted to moths. The flower opens; its stigma is closed; the projecting stamens scatter the loose pollen upon



the moth as it sips close at the blossom's throat, and as it flies from flower to flower it conveys it to other blossoms whose stigmas are matured. The expression of the normal bud is thus one of affinity and hope.

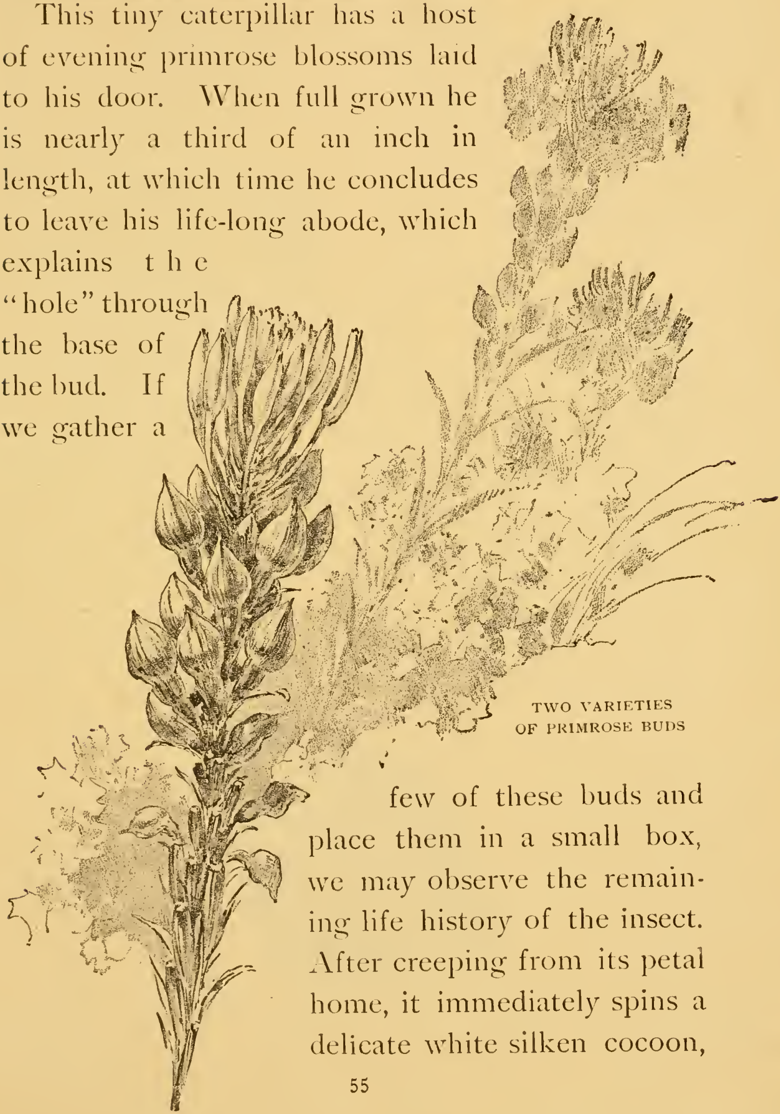
Our friend just quoted mentions having seen "holes" on the other swollen buds, and there is


"Many a perfume breathed
From plants that wake when
others sleep:
From timid buds that keep
Their odour to themselves
all day
But when the sunlight dies
away,
Let the delicious secret out
To every breeze that roams
about"

certain to be a hole in every one of them at its maturity. But let us select one which is as yet entire. If with a sharp knife-point we cut gently through its walls, we disclose the curious secret of its abnormal shape—"the worm i' the bud," as shown in my accompanying sketch—and what an eloquent

story of blighted hopes its interior condition reveals! This tiny whitish caterpillar, which we disclose in the petal dungeon, has been a prisoner since its birth, during the early growth of the bud. One by one the stamens and also the stigma have been devoured for food, until the mere vestiges of them now remain. With no stamens to bequeath pollen and no stigma to welcome other pollen, what need to open, what need to elongate a corolla tube for the tongue of a moth whose visit could render no functional service? So thus our blighted buds refuse to open, where blooming would be but a mockery.

This tiny caterpillar has a host of evening primrose blossoms laid to his door. When full grown he is nearly a third of an inch in length, at which time he concludes to leave his life-long abode, which explains the "hole" through the base of the bud. If we gather a



TWO VARIETIES OF PRIMROSE BUDS

few of these buds and place them in a small box, we may observe the remaining life history of the insect. After creeping from its petal home, it immediately spins a delicate white silken cocoon,

and within a day or so changes to a chrysalis. At the expiration of about a fortnight, as we open the box, we are apt to liberate one or more tiny gray moths, which, upon examination, we are bound to confess are a poor recompense for the blossom for which they are the substitute.

This little moth is shown very much enlarged in the accompanying tail-piece. Its upper wings are variously mottled with gray and light brown, and thickly fringed at their tips, while the two lower wings are like individual feathers, fringed on both sides of a narrow centre. These and other characters ally the insect with the great group known as the *Tineidæ*, of which the common clothes-moth is a notorious example.

The Noonday Lesson of the Primrose

Having learned the twilight lesson of the waiting bud, go out now in the hot, sunny noontime and stroll among your withered primroses, and see what they can teach you.

These faded blooms, in which so few of us have the slightest interest, may often be seen hanging like a chime of bells on the drooping stems for twenty-four hours after they first bow their heads. Who has guessed their pretty mystery?

Is this a mere withered, useless blossom that droops upon its stem? Is it not rather the prettiest luminous fairy tent that ever sheltered a day dream? Last night, when its four green sepals burst from their cone, and sprang backward to release their bright, glossy petals, a small moth quickly caught the signal and settled in quivering

contentment, sipping at its throat. Its wings were of the purest rose-pink, bordered with yellow.

All through the night it fluttered among the fresh opening flowers, one of a countless host of feathery nocturnal moths and "millers." But as the sunrise has stolen upon these primroses, the fickle broods have all forgotten the flowers and dispersed afar. "All," did I say? Oh, no; not all. Let us turn to our withered blossoms and, one by one, look within their bells. Here is one that falls even at our approach, plainly the blossom of night before last. We will turn our attention only to last night's flowers.

Many show no peculiarity, but at length we find one that appears to have an extra petal folded within its throat, and upon opening the folds, we disclose our faithful nursling with pink and yellow wings, whom we saw last night fluttering from flower to flower, sipping its sweets and bearing its golden pollen from cup to cup. The earliest twilight sipper, that even on the approach of dawn is loath to leave the flower, and creeps into the wilted bloom, where it remains concealed through the following day, and doubtless occasionally falls with it to the ground.

In the color of its markings we find an outward

expression of its beautiful sympathy, the yellow margins of the wings, which protrude from the flower, being quite primrose-like, and the pink being reflected in the rosy hue which the wilting primrose petals so often assume, especially at the throat.

These pretty moths are by no means rare. A careful search is quite certain to disclose a number of them. I once found three secreted in the flowers of a single plant.

The progeny of our tiny pink and yellow moth will feed upon the young seed-pods of the primrose at a later date. They are smooth, green caterpillars which so exactly resemble in size and shape the seed-pods themselves that even a vireo or worm-eating warbler, who is supposed to know a green caterpillar when he sees one, might perch among these without a suspicion, except, perhaps, at the tickling of its feet by the rudely touched victim.

Nearly all insect-eating birds are very fond of these green caterpillars, so that doubtless none would ever reach the moth stage, and the primroses would be robbed of their benefactors if their protective coloring was less perfect.

Even in winter, when the stories of the waiting bud, the blighted blossom, the fairy tent, and the dainty pod are finished, the primrose still has a

lesson to teach—a lesson of wonderful beauty in its perfectly symmetrical leaf clusters, carpeting the earth with exquisite complex spiral stars, geometrical in their arrangement and perfect patterns for the modeller, sculptor, decorator, or wood carver.

The Riddle of the Bluets Guessed by Both Bees and Butterflies

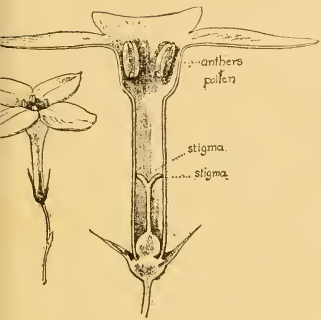


Fig. 1.

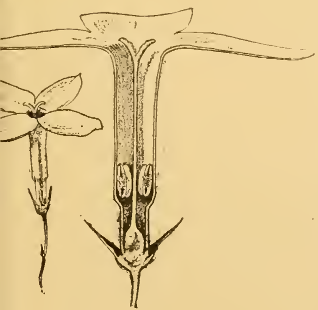


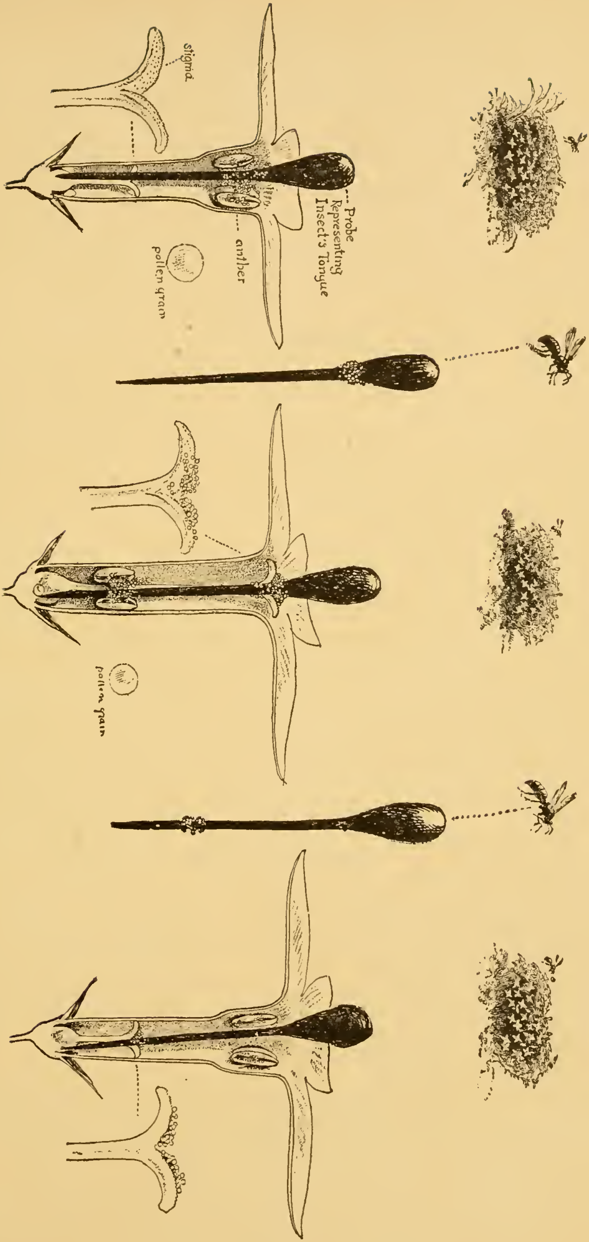
Fig. 2.

The little Quaker-ladies of the fields are by far the most interesting of the Madder family, and are also the best examples of what are known as "dimorphic" "heterostyled," or two-formed flowers that we have in our wild garden.

We all know these pretty, dainty bluets, whose galaxy of white or blue stars tints whole meadows like a light snowfall. Perhaps we may have chanced to notice that the flowers are not all constructed alike, but the probabilities are that we have *seen* them *all our lives* without discovering this fact, obvious as it is to the most casual observer.

If we pluck a few from this dense cluster beside the path, we observe that the throat of each is swollen larger than the tube beneath, and is almost closed by four tiny yellow anthers, Fig. 1. The next and the next clump may show us similar flowers; but after a little search we are sure of finding a cluster in which a new form appears, as shown in Fig. 2, in which the anthers at the opening are missing, and their place supplied with a little forked stigma! The tube below is larger than the first flower for about two-thirds its length, when it suddenly contracts, and if we cut it open we find the four anthers secreted near the wide base of the tube. What does it mean, this riddle of the bluets? This is simply the little plan which the Houstonia has perfected to insure its cross-fertilization by an insect, to compel an insect to carry its pollen from one flower and deposit it upon the stigma of another. Once realizing this as the secret, we can readily see how perfectly the intention is fulfilled.

In order to make it clear, I have drawn a progressive series of pictures, which hardly require description. The flowers are not highly developed enough to have a special insect sponsor. They are visited by various small bees, butterflies and other insects. At the left is an insect just alighting


stigma
Probe
Representing
Insect's Tongue
anther
pollen grain
pollen grain

on a clump of the blossoms of the high-anther form indicated below it. The black probe represents the insect's tongue, which, as it seeks the nectar at the bottom of the tube, gets dusted at its thickened top with the pollen from the anthers. We next see the insect flying away, the probe beneath indicating the condition of its tongue. It next alights on clump No. 2, in which the flowers happen to be of the high-stigma form, as shown below. The tongue now being inserted brings the pollen against the high stigma, and fertilizes the flower, while at the same time its tip comes in contact with the low anthers, and gets pollen from them. We next see the insect flying to clump No. 3, the condition of its tongue being shown below. Clump No. 3 happens to be of the first low-stigma form of flowers, and as the tongue is inserted the pollen at its tip is carried directly to the low stigma, and *this* flower is fertilized from the pollen from the anthers on the same level in the previous flower. And thus the riddle is solved by the insect. From clump to clump he flies, and through his help each one of the pale blue blooms is sure to get its food, each flower fertilized by the pollen of another.

Another beautiful provision is seen in the difference in size of the pollen-grains of the two flowers,

those of the high anthers being much larger than those from the lower anthers. These larger grains are intended for the high stigma, which they are sure of reaching, while those of smaller size, on the top of the tongue, which should happen to be wiped off on the high stigma, are too small to be effective for fertilization, accomplishing their purpose only when deposited on the low stigma to which they are adapted.

The flowers with high stigmas and low stamens are never found on the same plant as those with low stigmas and high stamens—in fact, the two forms grow in separate patches.

The stigma of either variety is rarely exactly the same length as the stamen producing the pollen which will fertilize it, but the variation is very slight.

The little meadow fritillary, *Brenthis bellona*, is the chief butterfly visitor of the bluets, but it is not nearly so effective a worker as the small bees that also sip these sweets, since it is apt to fertilize only the short-styled blossoms, avoiding the stigma in the long-styled flowers, and sipping their honey from the side.

Much the same mechanism that distinguishes the bluets may be seen in the flax, the partridge-berry, the bouvardia, and the cowslip.

The purple loosestrife, *Lythrum Salicaria*, produces flowers whose stamens and pistils occur in three different lengths. In this species only pollen from the longest stamens can fully fertilize the longest pistils; only that from the shortest stamens the shortest pistils, and only that from the medium-length stamens the medium-length pistils.

The common wood-sorrel and the blue pickerel weed also produce trimorphic or three-formed flowers.

Compositæ Manners and How they Charm the Insects

If the dainty mechanism shown in the barberry, pulse, primrose, and madder families excites our wonder, what shall be said of the revelations in the great order of the Compositæ, where each so-called flower, as in the dandelion, daisy, cone-flower, marigold, thistle, golden-rod, aster, and innumerable other species, is really a dense cluster of minute flowers, each as perfect in its construction as in the examples already mentioned, each with its own peculiar plan designed to insure the transfer of its own pollen to the stigma of its neighbor, while excluding it from its own?

All summer long the cone-flower, or brown-eyed Susan, *Rudbeckia hirta*, shown in the chapter heading, blooms in our fields; but how few of us imagine the strange processes which are being enacted in that purple cone! Let us examine it

closely. If we pluck one of the blossom's heads and keep it in a vase overnight, we shall probably see on the following morning a tiny yellow ring of pollen encircling the outer edge of the cone. In this way only are we likely to see the ring in its perfection, as in a state of nature the wind and insects rarely permit it to remain.

If we now with a sharp knife make a vertical section, as shown at Fig. 1, we may observe

Fig. 1.

the conical receptacle studded with its embryo seeds, each bearing a tiny tubular blossom. Three distinct forms of these flowers are to be seen. The lower and older ones are conspicuous by their double feathery tails, the next by their extended anthers bearing the pollen at their extremity, and above these again the buds in all stages of growth. These various states are indicated in Fig. 2.

As in all the Compositæ, the anthers are here united in a tube, the pollen being discharged within.

At the base of this anther-tube rises the pistil, which gradually elongates, and like a piston forces out the pollen at the top. Small insects, in creeping over the cone, quickly dislodge it. In the next stage the anthers have withered, the flower-tube elongated, and the top of the two-parted pistil begins to protrude, and at length expands its tips, disclosing at the centre the stigmatic surface, which

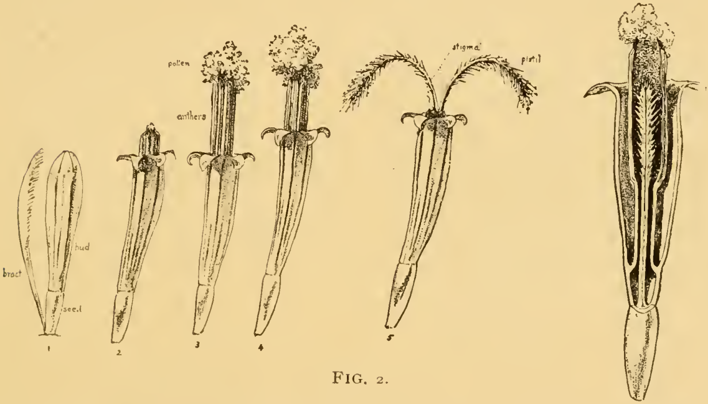


FIG. 2.

has until now been protected by close contact, as shown in the section at the right of Fig. 2.

A glance at Fig. 2 will reveal the plan involved. The ring of pollen is inevitably scattered to the stigmas of the neighboring flowers, and cross-fertilization continually insured. Similar contrivances are to be found in most of the Compositæ, through the same method being variously applied.

The practice followed by the Compositæ of grouping many small flowers in one head is unrivalled for utility in the floral world. It is, however, only one of the many thrifty traits which have enabled these hardy folk to penetrate to all quarters of the globe. They spare no effort to insure success, attracting both pollen-gatherers and nectar-seekers, and still, not quite certain but that both these classes may sometime fail them, reserving the power of self-fertilization for such an extremity.

Their method, too, of scattering their seed as shown in the dandelion and thistle has aided their march around the world. One cannot help admiring their persistency and delighting in their beauty, despite the farmer's lament.

The Mountain Laurel's Embrace

Let us now look at the Heath family. The family of the heath, cranberry, pyrola, Andromeda, and mountain-laurel—how do these blossoms welcome their insect friends? This group is particularly distinguished by the unusual exception in the form of its anthers, which open by pores at their tips, instead of the ordinary side fissures. Two or

three forms of these anthers are shown in my row of stamens, page 25.

Seen thus in their detached condition, how incomprehensible and grotesque do they appear! And yet, when viewed at home, in their bell-shaped corollas, their hospitable expression and greeting are seen to be quite as expressive and rational as those of other flowers. Take the mountain-laurel, for instance; what a singular exhibition is this which we may observe on any twilight evening in the laurel copse, the dense clusters of pink-white bloom waited upon by soft-winged fluttering moths, and ever and anon celebrating its cordial spirit by a mimic display of pyrotechnics as the anthers hurl aloft their tiny showers of pollen!

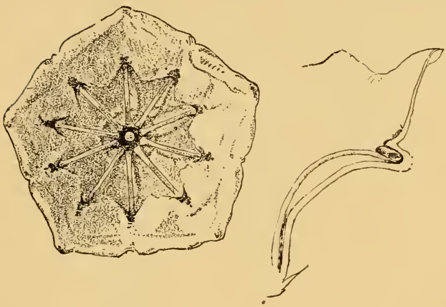


FIG. 1.

Every one is familiar with the curious construction of this flower, with its ten radiating stamens, each with its anther snugly tucked away in a pouch at the rim of its saucer-shaped corolla. Thus they appear in the freshly opened flower, and thus will they remain and wither if the flower is brought

in-doors and placed in a vase upon our mantel. Why? Because the hope of the blossom's life is not fulfilled in these artificial conditions; its natural counterpart, the insect, has failed to respond to its summons.

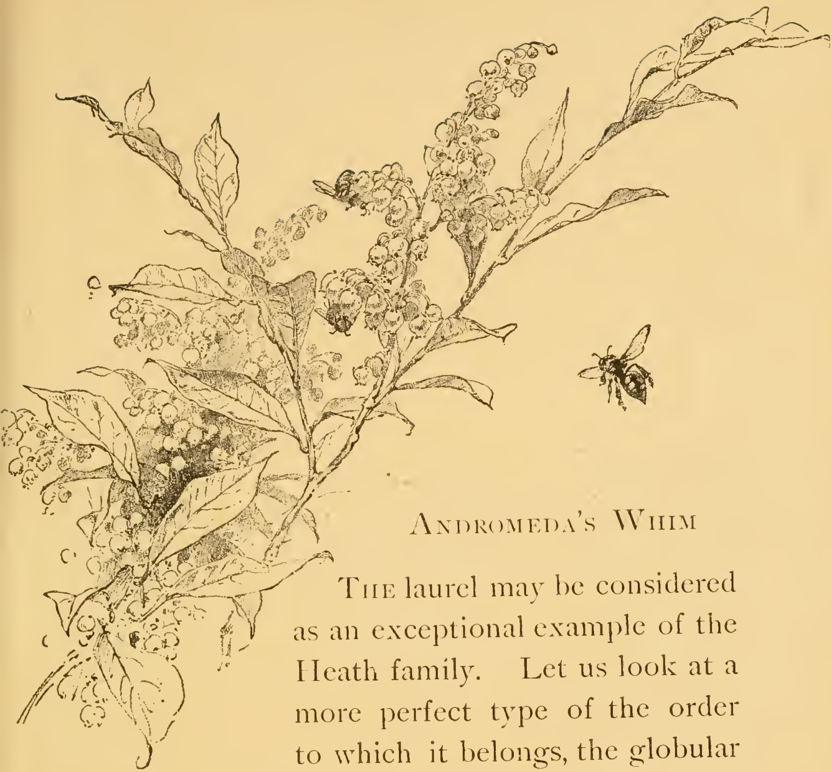
But the twilight cluster in the woods may tell us a pretty story. Here a tiny moth hovers above the tempting chalice, and now settles upon it with eager

FIG. 2.

tongue extended for the nectar at its centre. What an immediate and expressive welcome! No sooner has this little feathery body touched the filaments than the eager anthers are released from their pockets, and, springing inward, clasp their little visitor, at the same time decorating him with their compliments of webby pollen, A, Fig. 2.

The nectary now drained of its sweets, the moth creeps or flutters to a second blossom, and its pollen-dusted body thus coming in contact with its stigma, cross-fertilization is accomplished. The pollen of the laurel differs from that of most of the Heath blooms, its grains being more or less adherent by a cobwebby connective which permeates the mass as indicated in my magnified representation, B, Fig. 2.

It is probable that an accessory cross-fertilization frequently results from a mass of the pollen falling directly upon the stigma of a neighboring blossom, or even upon its own stigma; but even in the latter case, as has been absolutely demonstrated as a general law by the experiments of Darwin, the pollen from a separate flower is almost invariably prepotent, and leads to the most perfect fruition, and thus to the survival of the fittest—the cross-fertilized. And, in any event, the insect is to be credited for the release of the tiny catapults by which the pollen is discharged.



Andromeda's Whim

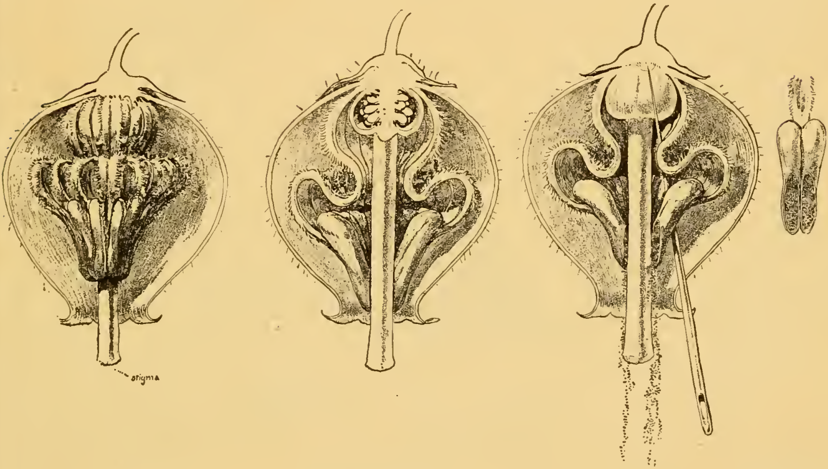
The laurel may be considered as an exceptional example of the Heath family. Let us look at a more perfect type of the order to which it belongs, the globular blossom of the Andromeda, *A. ligustrina*.

Only a short walk from my studio door in the country I recently observed its singular reception to the tiny black-and-white banded bee, which seems to be its especial companion, none the less constant and forgiving in spite of a hospitality which, from the human standpoint, would certainly seem rather discouraging. Fancy a morning call upon your particular friend. You knock at the

door, and are immediately greeted at the threshold with a quart of sulphur thrown into your face. Yet this is precisely the experience of this patient little insect, which manifests no disposition to retaliate with the concealed weapon which on much less provocation he is quick to employ. Here he comes, eager for the fray. He alights upon one of the tiny bells scarce half the size of his body. Creeping down beneath it, he inserts his tongue into the narrowed opening. Instantly a copious shower of dust is poured down upon his face and body. But he has been used to it all his life, and by heredity he knows that this is Andromeda's peculiar whim, and is content to humor it for the sweet recompense which she bestows. The nectar drained, the insect, as dusty as a miller, visits another flower, but before he enters must of necessity first pay his toll of pollen to the drooping stigma which barely protrudes beneath the blossom's throat, and the expectant seed-pod above welcomes the good tidings with visions of fruition.

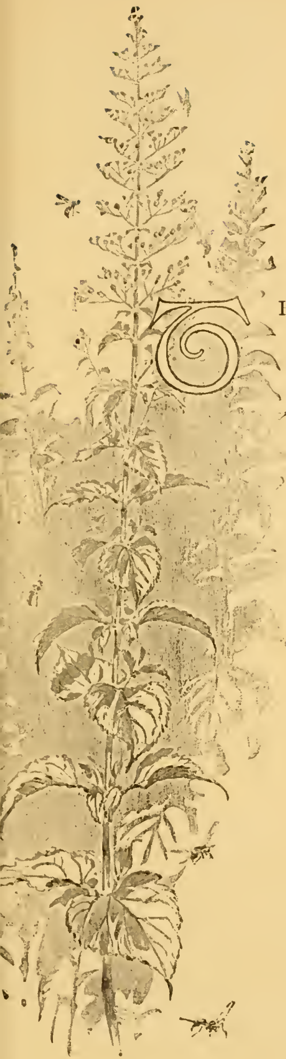
And how beautiful is the minute mechanical adaptation by which this end is accomplished! This species of Andromeda is a shrub of about four feet in height, its blossoms being borne in close panicled clusters at the summit of the

branches. The individual flower is hardly more than an eighth of an inch in diameter. From one of three blossoms I made the accompanying series of three sectional drawings. The first shows the remarkable interior arrangement of the ten stamens surrounding the pistil. The second presents a sectional view of these stamens, showing their peculiar



S-shaped filaments and ring of anthers—one of the latter being shown separate at the right with its two pores and exposed pollen. The freshly opened blossom discloses the entire ring of anthers in perfect equilibrium, each with its two orifices closed by close contact with the style, thus retaining the pollen. It will readily be seen that an insect's

tongue, as indicated by the needle, in probing between them in search for nectar, must needs dislocate one or more of the anthers, and thus release their dusty contents, while the position of the stigma below is such as to escape all contact.



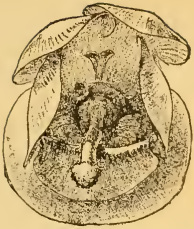
The Homely Figwort Attractive to Mistress Wasp

In my initial illustration is shown a sketch of the figwort, or *Scrophularia*, a tall, spindling, and apparently altogether uninteresting weed. It has rather fine, luxuriant leaves, it is true, but the tall, curiously branching spray of small, purplish-olive flowers is very insignificant. Though so ordinary in appearance, this weed has the honor of giving its name to its large and important family, other common members of which are the toadflax, butter-and-eggs, and foxglove. The figwort has not even a perfume, like the mignonette, to atone for its plainness ; but it has an odor, if not a perfume, and it has a nectary

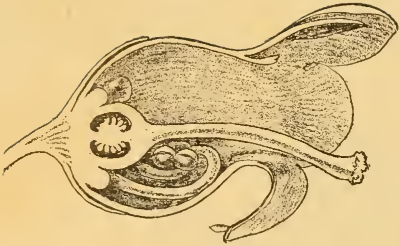
which secretes the beads of sweets for its pet companion insects, which in this instance do not happen to be bees or butterflies, but most generally wasps of various kinds, as these insects are not so particular as to the quality of their tipple as bees are apt to be. But the figwort has found out gradually through the ages that *wasps* are more serviceable in the cross-fertilization of its flowers than other insects, and it has thus gradually modified its shape, odor, and nectar especially to these insects.

Let us, then, take a careful look at these queer little homely flowers, and for the time being consider them as mere devices — first, to insure the visit of an insect, and, second, to make that insect the bearer of the pollen from one blossom to the stigma of another. Here we see a flower with three distinct welcomes on three successive days.

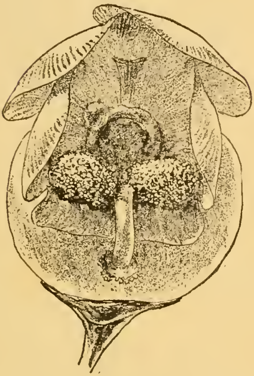
The flower-bud usually opens in the morning, and shows a face as at A, which must be fully understood by looking at the side section shown at A^1. The anthers and pollen are not yet ripe, but the stigma is ready, and now guards the doorway. To-morrow morning we shall see a new condition of things at that doorway, as seen at B and B^1. The stigma has now bent down out of the way, while two anthers have unfolded on their stalks and now



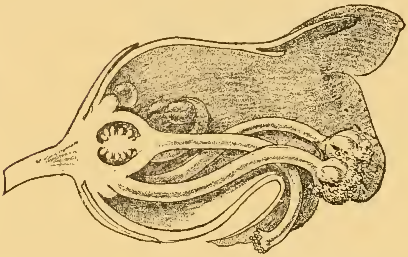
A. First Day's Welcome. Stigma at the Doorway.



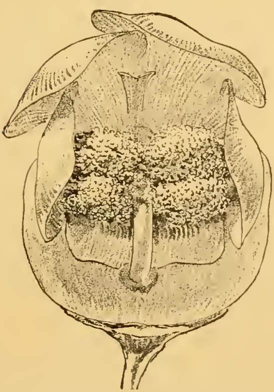
A¹. First Day. Sectional View.



B. Second Day's Welcome. Stigma bent downward beneath two withered Stamens at the Doorway.



B¹. Second Day. Sectional View.



C. Third Day's Welcome. Four Stamens at the Doorway.

D. Fourth Day. Fall of Blossom. Its mission fulfilled.

shed their pollen at the threshold. The third morning, or perhaps even sooner, the other pair come forward, and we see the opening of the blossom as at C. Blossoms in all these three conditions are to be found on this cluster.

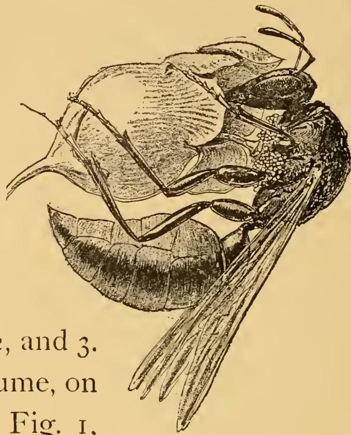


FIG. 1.

A small wasp is now seen hovering about the flowers, and we must turn our attention to him as seen in Figs. 1, 2, and 3. The insect alights, we will assume, on a blossom of the second day, Fig. 1, clinging with all his feet, and thrusting his tongue into the beads of nectar shown at A^1 and B^1. He now brings his breast or thorax, or perhaps the underside of his head, against the pollen, and is thoroughly dusted with it. Leaving the blossom, we see him in flight, as at Fig. 2, and very soon he is seen to come to a freshly opened flower, which he sips as before. The pollen is thus pushed against the projecting stigma, as

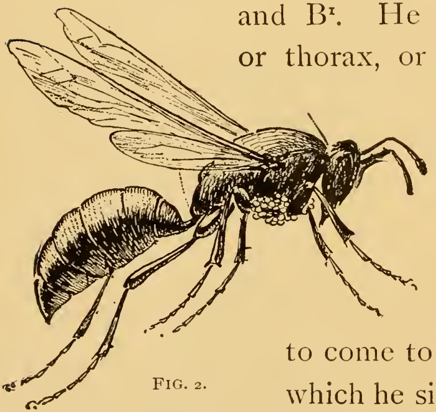


FIG. 2.

shown at Fig. 3, and thus, one by one, the flowers are cross-fertilized.

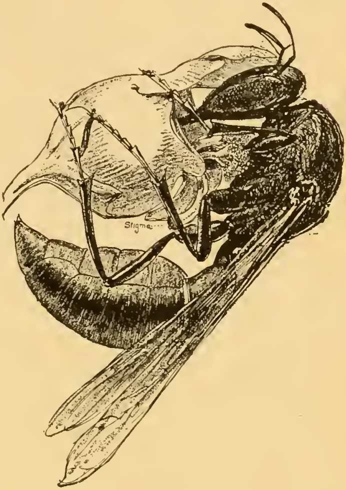
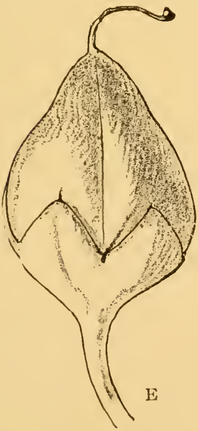


FIG. 3.

The stigma, after receiving pollen, immediately bends downward and backward, as shown in B', to give place to the ripening anthers, and shortly after the last pair of them have shed their pollen, the blossom, having then fulfilled its functions, falls off, as shown at D. This may be on the afternoon of the third day, or not until the fourth. If not visited by insects, it may chance to remain the longer time; but more than one tiny wasp gets his head into such a blossom, and is surprised with a tumble, his weight pulling the blossom from its attachment.



E

The result of that pollen upon the stigma is quickly seen in the growing ovary or pod, which enlarges rapidly on the few succeeding days, as in E. Many species of hornets and wasps, large and

small, are to be seen about the figwort blooms, occasionally bees, frequently bumblebees, which usually carry away the pollen on the underside of their heads. Who shall any longer refer to the figwort as an "uninteresting weed"?

The Wood-Betony, a Protégé of the Bumblebee

Even here at our elbow in the woods is a plant which we have all known since childhood. The wood-betony, it is called—to select its worthier title, *Pedicularia Canadensis*—a common early flower of our woods, closely allied to the figwort, and blooming in company with the uvularia, Solomon's-seal, crane's-bill, downy yellow violet, and

others. The plants grow in fern-like tufts, with scattered blossom heads of varied shades of yellow, pink, or even carmine.

I remember reading, a few years since, a remark by a prominent botanical authority concerning this flower, observing that its fertilization was a puzzle, as insects were rarely to be found upon it, which observation, taken together with what I had observed of the strange form and disposition of the blossoms, and the curiosity awakened by my reading, possessed a peculiar significance for me.

In the light of Darwin's and Müller's pages, how eagerly I now sought the haunt of my wood-betony, and how readily, too, it disclosed the secret which had heretofore escaped me as well as other earnest though too hasty seekers! Visiting a certain wood path, where the plants grew in profusion, I seated myself among them, and observed carefully. It was in the middle of May, and the flowers were in their prime, and in such omnipresent profusion that I felt assured some honey-seeking insect must soon be tempted thither among the tens of thousands of brimful nectaries.

I had not long to wait before a well-known "drowsy hum" fell upon my ear, and a large bumblebee alighted upon a flower-head close by.

In his habitual impetuous fashion, he rifled the sweets from one and another of the blossom-heads, so lost in his absorbing work that I was permitted to steal close upon him and observe his eager method, for method, indeed, there was in every movement. In almost every instance he made his approach to the base of the flower-head, and followed around the spiral arrangement of the flowers to the summit of the cluster.

It needed only a single glance to receive an instant revelation of the reason which lay beneath this singular and always heretofore mysterious spiral arrangement of the flowers — their spiral arrangement not only, but the individual lateral curve of each separate blossom, which in every case brought the opening of its tube facing to the left. A moment's careful attention to my burly little interpreter revealed also the strange utility of the singular fissure down the right side of each corolla—a slit in the flower-tube extending from its throat half way to the base of the tube, but only on one side. Why on one side and not on the other? Why always on this outer curve of the flower? These had been questions which I had frequently asked myself when examining this queer, one-sided formation. But they were now answered to my satisfaction.

The whole arrangement of these flowers, together with their individual tendencies, show a direct, conscious affiliation to the bumblebee, affording as perfect an illustration of the sympathetic dependence between flower and insect as we may find among the wonders of the orchid tribe so beautifully and clearly disclosed by Darwin.

What is this peculiar spiral progression, if not an inducement of convenience—an inviting flight of stairs, as it were? What is this individual turning about of each separate flower, if not a welcome invitation to its heart? and what is this strange fissure at the side but a facility to aid and to "speed the parting guest"? And through all this, how beautifully, by what wondrous art, has his mission been fulfilled! Observe our bee closely with me. He now alights obliquely at the base of a flower-head, inserts his head deep within the tube of the lowest flower, the strange fissure assisting in the expansion of its tube while his long tongue probes its nectary. His wedge-shaped head has forced apart the compressed sides of the corolla, thus opening the pollen-box (the compressed anthers) within the walls of the arched tip of the flower, the yellow fertilizing powder falling upon his head.

He has now emptied the horn of plenty, when, almost without withdrawing his head, he slips his tongue through the ready exit—the fissure in the flower-tube—to find an expectant, inviting face turned toward him, and in the most convenient possible attitude for his kiss.

He proceeds as before, but not until he has unwittingly paid his toll and won his right of way, having deposited the requisite touch of pollen upon the overhanging tip of the stigma, and thus cross-fertilized the flower. And thus he pursues his course to the summit of the spiral, carrying from its latest anthers a vivifying touch which secures in the next flower-head he visits the still more important function of absolute cross-fertilization from a separate plant. Indeed, it is doubtful whether the pollen from separate heads is not more or less continually intermingled, and this end secured in all the flowers, considering that only a grain or two of the thousands are required to insure the fertilization of the ovules.

Within an hour after the discovery of the first bee upon the wood-betony, the woods were murmuring with their mingled hum. I counted twenty of the insects at work within a radius of ten feet, and wondered that I could previously have been so blind

to this marvellous drama which the winged actors of wayside and thicket had been enacting every day from April to June for centuries past.

Sage Tea for the Bees—Horse-Balm Honey

The sage is representative of the large botanical order known as the Mint family,* the labiates, or gaping, two-lipped flowers, the arched hood here answering to the upper lip, the spreading base forming the lower lip, which is usually designed as a convenient

* Nearly all our savory herbs belong to this family—thyme, savory, rosemary, spearmint, hyssop, pennyroyal, lavender, etc.

threshold for the insects while sipping the nectar deep within the tube.

Every one is familiar with this old-fashioned favorite of the country garden, its lavender flowers arranged in whorls in a long cluster at the tip of the stem. One of these flowers, a young one from the top of the cluster, is shown at A, Fig. 1, in section, the long, thread-like pistil starting from the ovary, and curving upward beneath the arch of the flower, with its forked stigma barely protruding (B). There are two of the queer stamens, one on each side of the opening of the blossom, and situated as shown, their anthers concealed in the hood above, and only their lower extremity appears below, the minute growth near it being one of the rudiments of two former stamens which have become aborted.

If we take a flower from the lower portion of the cluster (D), we find that the thread-like pistil has been elongated nearly a third of an inch, its forked stigma now hanging directly at the threshold of the flower. The object of this will be clearly demonstrated if we closely observe a bee upon the blossoms. Let us suppose he has reached the top of the cluster among the younger blossoms. He creeps up the outstretched platform of the flower,

and has barely thrust his head within its tube when down comes the pair of clappers on his back (C). Presently he backs out, bearing a generous dab of yellow pollen, which is further increased from each subsequent flower. He has now finished this cluster, and flies to the next, alighting as usual on the lowermost tier of bloom. In them the elongated stigma now hangs directly in his path, and comes in contact with the pollen on his back as the insect sips the nectar. Cross-fertilization is thus insured, and, moreover, cross-fertilization not only from a distinct flower, but from a separate cluster, or even a separate plant; for in these older stigmatic flowers the anther, as it comes down upon his back, is seen to be withered, having shed its pollen several days since, the supply of pollen on the bee's body being sufficient to fertilize all the stigmas in the cluster, until a new supply is obtained from the pollen-bearing blossoms above. And thus he continues his rounds.

FIG. 1.

Only a few days since, while out on a drive, I passed a luxuriant clump of the plant known as "horse-balm." I had known it all my life, and twenty years previously had made a careful analytical drawing of the mere botanical specimen. What could it say to me now in my more questioning mood? Its queer little yellow-fringed flowers hung

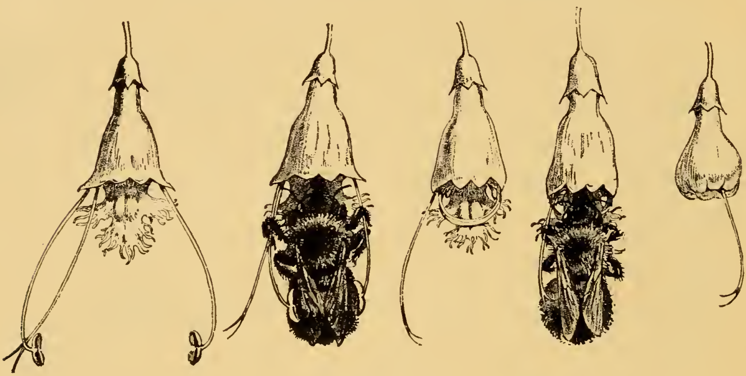
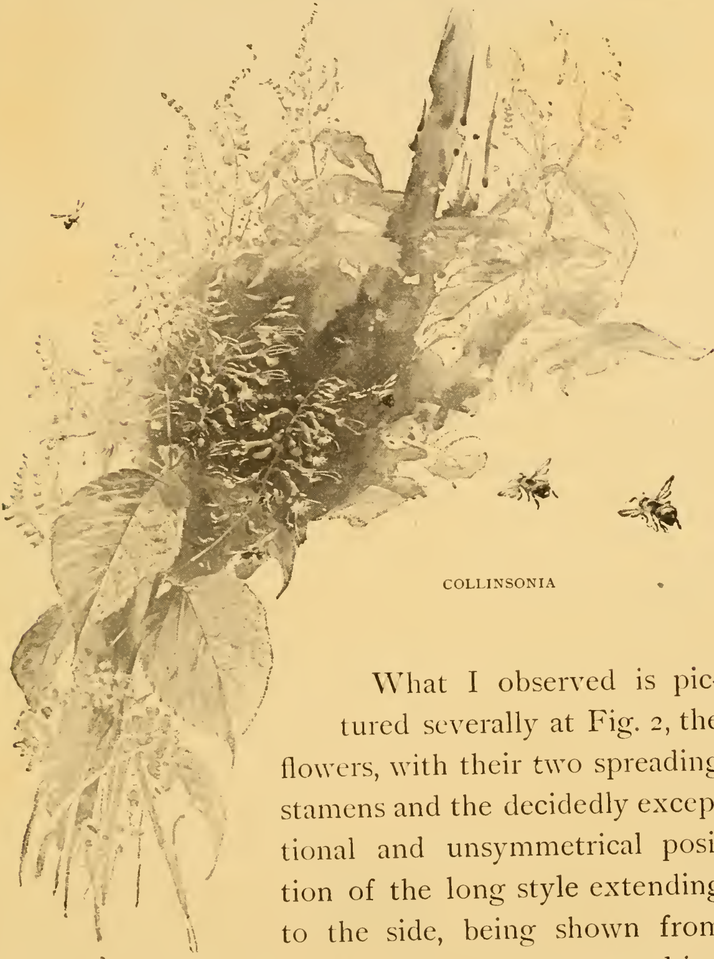


FIG. 2.

in profusion from their spreading terminal racemes. I recalled their singular shape and the two outstretched stamens protruding from their gaping corolla, and could distinctly see them as I sat in the carriage. I had never chanced to read of this flower in the literature of cross-fertilization, and murmuring, half aloud, "What pretty mystery is yours, my Collinsonia?" prepared to investigate.



COLLINSONIA

What I observed is pictured severally at Fig. 2, the flowers, with their two spreading stamens and the decidedly exceptional and unsymmetrical position of the long style extending to the side, being shown from above. A small nectar-seeking bumblebee had approached, and in alighting upon the fringed platform grasped the filaments for

support, and thus clapped the pollen against his sides. Reasoning from analogy, it would of course be absolutely clear that this pollen has thus been deposited where it will come in contact with the stigma of another flower. So, of course, it proved. In the bee's continual visits to the several flowers, he came at length to the younger blooms, where the forked stigmas were turned directly to the front, while the immature stamens were still curled up in the flower tubes. Even the unopened buds showed a number of species where the early matured stigma actually protruded through a tiny orifice in precisely the right position to strike the pollen-dusted body of the bee, as he forced his tongue through the tiny aperture.*

*In numerous instances observed since the above was written, I have noted the larger bumblebees upon the blossom. These insects have a different method of approach, hanging beneath the flower, the anthers being clapped against their thorax at the juncture of the wings instead of the abdomen, as in the smaller bee.

The Milkweed: A Bluebeard Blossom

The milkweed as food for the progeny of certain species of butterflies was considered in "Sharp Eyes"; the present article, therefore, is devoted to the singular hospitality which its blossoms extend to the bee, a hospitality which is nowhere matched among Flora's minions, and would seem occasionally in need of supervision.

Just outside the door here at my country studio, almost in touch of its threshold, year after year there blooms a large clump of the common milkweed, *Acclepias cornuta*, and, what with the fragrance of its purple pompons and the murmurous music of its bees, its fortnight of bloom is not permitted to be forgotten for an instant. Only a moment ago a whiff of more than usual redolence from the open window at which I am sitting reminded me that the flowers were even now in the heyday of their prime, and the loud droning music betokened that the bees were making the most of their opportunities.

Yielding to the temptation, I was soon standing in the midst of the plants. The purple fragrant umbels of bloom hung close about me on all sides, each flower, with its five generous horns of plenty, drained over and over again by the eager sipping swarm.

But the July sun is one thing to a bee and quite another thing to me. I have lingered long enough, however, to witness again the beautiful reciprocity, and to realize anew, with awe and reverence, how divinely well the milkweed and the bee understand each other. After a brief search among the blossom clusters, I return to my seclusion with a few interesting specimens, which may serve as a text here at my desk by the open window.

Two months hence occasional silky messengers will float away from the glistening clouds about the open milkweed pods, but whoever thanks the bees of June for them? The flower is but a bright anticipation—an expression of hope in the being of the parent plant. It has but one mission. All its fragrance, all its nectar, all its beauty of form and hue are but means toward the consummation of the eternal edict of creation—"increase and multiply." To that end we owe all the infinite forms, designs, tints, decorations, perfumes, mechanisms,

and other seemingly inexplicable attributes. Its threshold must bear its own peculiar welcome to its insect, or perhaps to its humming-bird friend, or counterpart; its nectaries must both tempt and reward his coming, and its petals assist his comfortable tarrying.

Next to the floral orchids, the mechanism of our milkweed blossom is, perhaps, the most complex and remarkable, and illustrates as perfectly as any of the orchid examples given in Darwin's noble work the absolute divine intention of the dependence of a plant species upon the visits of an insect.

Our milkweed flower is a deeply planned contrivance to insure such an end. It fills the air with enticing fragrance. Its nectaries are stored with sweets, and I fancy each opening bud keenly alert with conscious solicitude for its affinity. Though many other flowers manage imperfectly to perpetuate their kind in the default of insect intervention, the milkweed, like most of the orchids, is helpless and incapable of such resource. Enclose this budded umbel in tarlatan gauze and it will bloom days after its fellow-blooms have fallen, anticipating its consummation, but no pods will be seen upon this cluster.

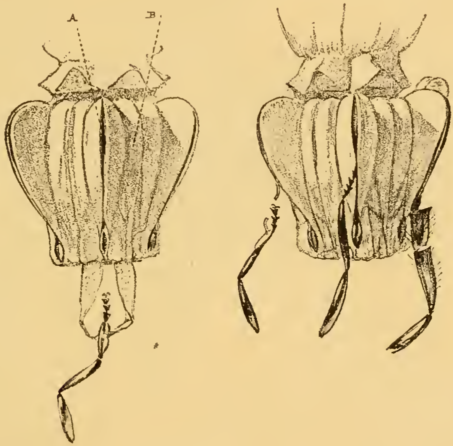
What a singular decree has Nature declared with

reference to the milkweed! She says, in plainest terms, "Your pollen must be removed on the leg of an insect, preferably a bee, or your kind shall perish from the face of the earth." And what is the deep-laid plan by which this end is assured? My specimens here on the desk will disclose it all.

Here are two bees, a fly, and a beetle, each hanging dead by its legs from a flower, an extreme sacrificial penalty, which is singularly frequent, but which was certainly not exacted nor contemplated in the design of the flower. A careful search among almost any good-sized cluster of milkweeds will show us many such prisoners. As in all flowers, the pollen of the milkweed blossom must come in contact with its stigma before fruition is possible. In this peculiar family of plants, however, the pollen is distinct in character, and closely suggests the orchids in its consistency and disposition. The yellow powdery substance with which we are all familiar in ordinary flowers is here absent, the pollen being collected in two club-shaped or, more properly, spatula-shaped masses, linked in pairs at their slender prolonged tips, each of which terminates in a sticky disk-shaped appendage united in V-shape below. These pollen masses are concealed in pockets (B) around the cylindrical centre of the

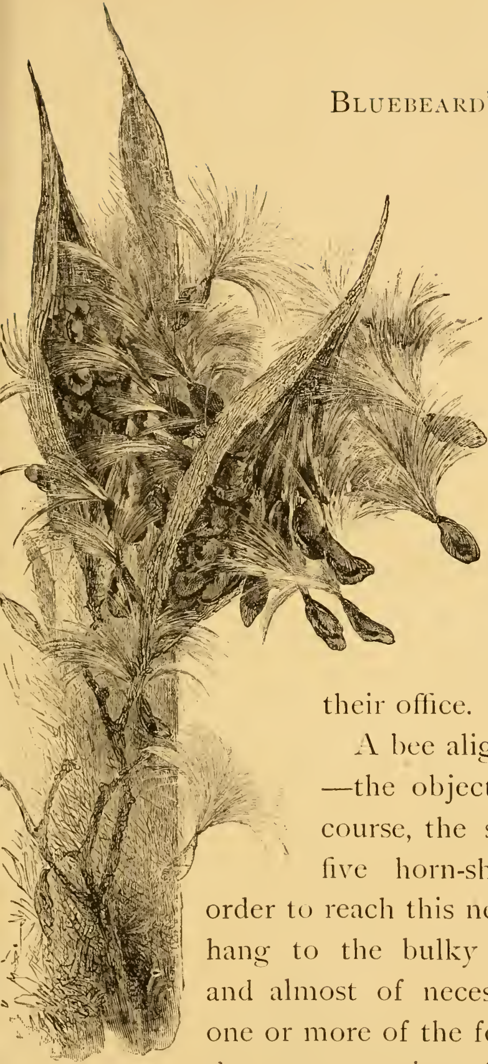
flower, the disks only being exposed at the surface, at five equidistant points around its rim, where they lie in wait for the first unwary foot that shall touch them.

A glance at the two views of this central portion of the flower, as it appears through my magnifying-



glass—the honey-horns and sepals having been removed—will, I think, indicate its peculiar anatomy or mechanism. No *stigma* is to be seen in the flower, the stigmatic surface which is to receive the pollen being concealed within five compartments, each of which is protected by a raised, tent-like covering, cleft along its entire apex by a fine fissure (A). *Outside of each of these and entirely*

separated from the stigma in the cavity lie the pollen masses within their pockets, each pair uniting at the rim below in V-shape, the union at the lower limit of the fissure.



Bluebeard's Methods

With a knowledge of the unusual structure of the milkweed blossom now at our disposal, let us visit the plant and observe clearly how its carefully planned and delicately adjusted members perform and sometimes exceed the duties of their office.

A bee alights upon the flower—the object of its visit being, of course, the sweets located in the five horn-shaped nectaries. In order to reach this nectar, the insect must hang to the bulky blossom. Instantly, and almost of necessity, it would seem, one or more of the feet are seen to enter the upper opening of the fissure, and during the insect's movements are drawn through to

the base. The foot is thus conducted directly between the two viscid disks, which immediately cling closer than a brother, and as the foot is finally withdrawn, it brings with it the pollen which it has pulled from its cell. The bee now released seeks a fresh flower, and the same result follows, the leg almost inevitably entering the fissure, and this time drawing in the pollen directly against the sticky stigmatic surface within. When the five honey-horns have been drained, and as our bee seeks to leave the flower, he is plainly detained by this too hearty "shake" or "grip" of his host, and quite often must exert a slight struggle to free himself. As the foot is thus forcibly torn away, the pollen mass is commonly scraped entirely off and retained within the fissure, or perhaps parts at the stalk, leaving the terminal disk clinging on the insect's leg. Occasionally, when more than one leg is entangled, the dangling blossom is tossed and swayed for several seconds by the vigorous pulling and buzzing, and a number of these temporary captives upon a single milkweed plant are always to be seen.

Not unfrequently the mechanism so well adapted exceeds its functions and proves a veritable trap, as indicated in my specimens. I have found three

dead bees thus entrapped in a single umbel of blossoms, having been exhausted in their struggles for escape; and a search among the flowers at any time will show the frequency of this fatality, the victims including gnats, flies, crane-flies, bugs, wasps, beetles, and small butterflies. In every instance this prisoner is found dangling by one or more legs, with the feet firmly held in the grip of the fissure.

Almost any bee which we may catch at random upon a milkweed gives perfect evidence of his surroundings, his toes being decorated with the tiny yellow tags, each successive flower giving and taking, exchanging compliments, as it were, with its fellows. Ordinarily this fringe can hardly prove more than an embarrassment; but we may frequently discern an individual here and there which for some reason has received more than his share of the milkweed's compliments. His legs are conspicuously fringed with the yellow tags. He rests with a discouraged air upon a neighboring leaf, while honey, and even wings, are seemingly forgotten in his efforts to scrape off the cumbersome handicap.

An interesting incident, apropos of our embarrassed bee, was narrated to me by the late Alphonso

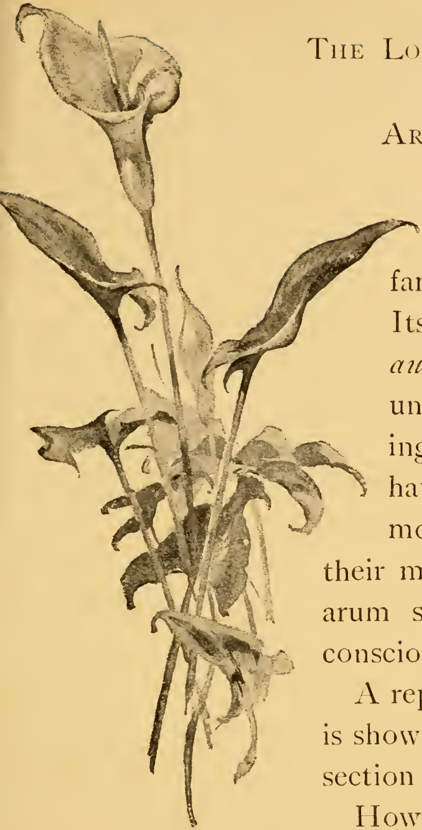
Wood, the noted botanist. He had received by mail from California a small box containing a hundred or more dead bees, accompanied by a letter. The writer, an old bee-keeper, had experience, and desired enlightenment and advice. The letter stated that his bees were "dying by thousands from the attacks of a peculiar fungus." The ground around the hive was littered with the victims in all stages of helplessness, and the dead insects were found everywhere at greater distances scattered around his premises.

It needed only a casual glance at the encumbered insects to see the nature of the malady. They were laden two or three layers deep, as it were, with the pollen masses of the milkweed. The botanist wrote immediately to his anxious correspondent, informing him, and suggesting as a remedy the discovery and destruction of the mischievous plants, which must be thriving somewhere in his neighborhood. A subsequent letter conveyed the thanks of the bee-keeper, stating that the milkweeds—a whole field of them—had been found and destroyed, and the trouble had immediately ceased.

I am not aware that Mr. Wood ever ascertained the particular species of milkweed in this case. It is not probable that our Eastern species

need ever seriously threaten the apiary, though unquestionably large numbers of bees are annually destroyed by its excessive hospitality.

Allied to the milkweed is another plant, the dogbane, *Apocynum*, which has a similar trick of entrapping its insect friends. Its drooping, fragrant, bell-shaped white flowers and long slender pods will help to recall it. But its method of capture is somewhat similar to the milkweed. The anthers are divided by a V-shaped cavity, into which the insect's tongue is guided as it is withdrawn from the flower, and into which it often becomes so tightly wedged as to render escape impossible. I have found small moths dangling by the tongue, as seen in the illustration below.



The Lords and Ladies of the Arum Family

The most remarkable member of the Arum family is a British subject. Its method of welcome and *au revoir* to insects is unique and truly astonishing. All of the flowers we have so far examined are more or less automatic in their movements, but the wild arum seems to display almost conscious mechanism.

A representation of this arum is shown in Fig. 1, and a cross-section at A, properly indexed.

How confidently would the superficial—nay, even careful—examination of one of the old-time botanists have interpreted its structure: "How simple and perfect the structure! Observe how the anthers are placed so that pollen shall naturally fall directly on the stigmas and fertilize them!" Such would indeed appear to be intended, until it is actually discovered that the

stigmas have withered when the pollen is shed—a device which, acting in association with the little ring of hairs, tells a strange story. It is not my fortune to have seen one of these singular blossoms, but from the description of the process of fertilization given in Hermann Müller's wonderful work, aided by a botanical illustration of the structure of the flower, I am readily enabled to picture the progressive stages of the mechanism.

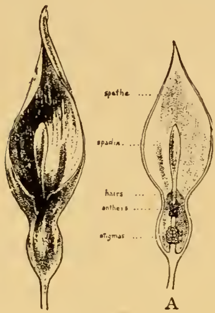


FIG. I.

In the first stage (B, Fig. 2), small flies with bodies dusted with pollen from a previous arum blossom are entering the narrowed tube, easily passing through the drooping fringe of hairs. Nectar is secreted by the stigmas, and here the flies assemble, thus dusting them with pollen. Their appetite temporarily satisfied, the insects seek escape, but find their exit effectually barred by the intruding fringe of hairs (C). In this second stage, the stigmas, having now been fertilized, have withered, at the same time exuding a fresh supply of nectar, which again attracts the flies, whereupon, as shown at D, the anthers open and discharge their pollen upon the insects. In the fourth stage (E),

all the functions of the flower having now been fulfilled, the fringe of hairs withers, and the imprisoned

FIG. 2.

pollen-laden flies are permitted to escape to another flower, where the beautiful scheme is again enacted.

JACK-IN-THE-PULPIT

These "lords" and "ladies"* of the village lanes are the foreign counterparts of our well-known Jack-in-the-pulpit, or Indian turnip, the sleek preacher of which stands so erect beneath his purple-streaked canopy.

Jack-in-the-pulpit, like the arum, has the streaked hood, and the "lords" and "ladies" dwell generally

* The arums with the purple-tinged hoods are called the "lords" and those with light green hoods the "ladies," because this difference in color was formerly thought to indicate the sex of the flower within. Later investigations, however, prove that while the purple-tinged ones are more often "lords" than "ladies," they are not invariably "lords."

under separate canopies — that is, the stigmatic flowers and pistillate flowers are found in different blossoms. Jack stands, you will find, on a bulb which, in the pistillate flowers, is composed of small ovules, and, in the stigmatic flowers, is covered with thread-like filaments. As in the arum, the coloring of the hood is not an infallible guide to the sex of the flower.

Small fungus gnats visit these blossoms and are often imprisoned in their deep chambers, for, though entrance is easy, egress is difficult, the way being blocked by the projection of the spadix. Many insects escape from this prison cell through the folds of the floral envelope, but many others perish. It is thought that Jack-in-the-pulpit is in a transition state and that its plan to insure cross-fertilization is not yet perfected. This view is borne out by the fact that, although the intention of the plant is to separate its staminate and pistillate flowers, they are frequently found on the same spadix. When Jack has reached the ideal state which he aims at, his own and the insects' interests will be provided for in a better fashion.

THE HERMIT OF THE BOG

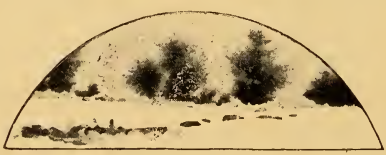
By far the humblest of all the arums is the skunk-cabbage. This lowly hermit of the bog is the first

living thing to extend to us a vernal greeting, actually braving the barriers of ice to bring us the message which it receives from mother earth long before the wood flower hears it in the south wind or the lisp of the bluebird tells it to the trees. For this reason, if no other, we should welcome our purple-mottled, hooded blossom, even though it is not graced with perfume nor blest with a poetic name and has not been fitted by nature to appear to advantage in a button-hole.

If you are disposed to question its right to the name of blossom, compare it with the beautiful calla, and you will at once recognize their kinship.

Observe, too, the throngs of flies and bees that hasten to visit its parlors. They long ago gave it a place in their posy, and though their taste may not accord with ours, their judgment cannot be disputed.

The stigmatic flowers mature on the skunk-cabbage's spadix before the pistillate ones. Like other blossoms with foul odors, this one is especially adapted for fertilization by scavenger flies. Though bees visit it, they probably do so because at the season when it blooms they have no choice of flowers, and not because it attracts them. Naturalized European bees are the chief visitors; and since our flora is not well adapted to them, they have to make many shifts, for a living, that cannot fail to be disagreeable. They often pay with their lives for their trespassing, for while the invited guests find no difficulty, the banquet finished, in leaving the blossom, the bee who has barely forced an entrance frequently fails to make good his escape through the narrow doorway, and either dies of starvation or falls a victim to the wise spiders who spread their catch-alls within these horns of plenty.



The Swaying Iris

"Born in the purple, born to joy and pleasance,
Thou dost not toil nor spin,
But makest glad and radiant with thy presence
The meadow and the lin."

We have the good fortune to number among our native wild flowers the beautiful fleur-de-lis, commonly called the blue-flag, the blossom chosen by the kings of France for their emblem.

The graceful family to which this blossom belongs has been most appropriately named for the youthful goddess of the rainbow, the fair lady Iris. Our flower, however, is a goddess in another court than that of Olympus, and her courtiers, though winged folk, can lay no claim to the supernatural. It may well be doubted, however, that the goddess of the clouds, in all the glory of court dress and attendance, ever presented a prettier picture than a company of these earthly flowers, set in velvety

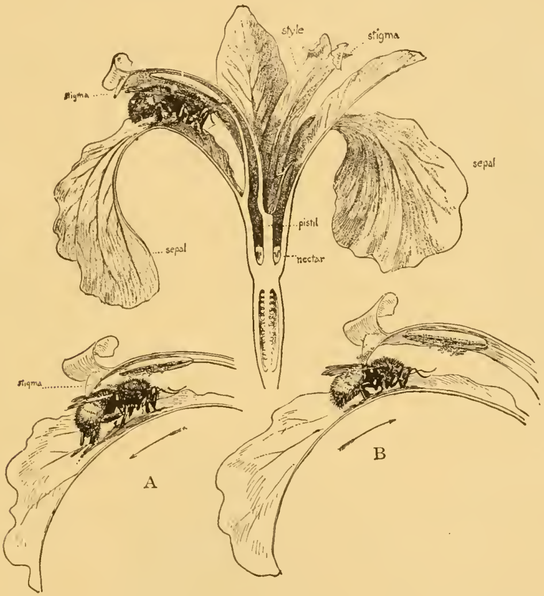
moss, clothed in royal purple, and surrounded by groups of gayly attired, fluttering admirers.

The blue-flag is a conspicuous example of a flower which has guarded itself against self-fertilization and which is beautifully calculated to secure the opposite result.

In most flowers, with the exception of the orchids, the stamens and pollen are plainly visible; but who ever sees the anthers of the blue-flag? Surely none but the analytical botanist and the companion insect to whom it is so artfully adjusted and so demonstrative. This insect is likely to be either a bumblebee or a species of large fly.

In apt illustration of Sprengel's theory of the "pathfinder," the insect does not alight at the centre of the flower, but upon one of the three large drooping sepals, whose veins, converging to the narrow trough above, indicate the path to the nectar. Closely overarching this portion is a long and narrow curved roof—one of three divisions to the style, each surmounting its veined sepals. Beneath this our visiting bee disappears, and a glance at my sectional drawing shows what happens. Concealed within, against the ridge-pole, as it were, the anther awaits his coming, and in his passage to and from the nectar below spreads its pollen over his head and back.

Having backed out of this segment of the blossom as shown at A, he proceeds to the next; but the shelf-like stigma awaits him at the door, and scrapes off or rubs off a few grains of the pollen from his back (B). Thus he continues until the third segment is reached, from which he carries away a fresh load of

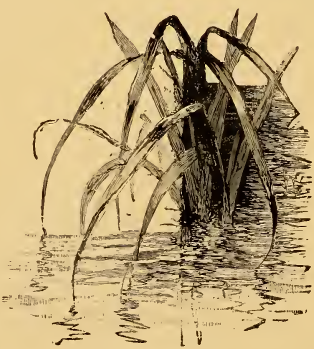


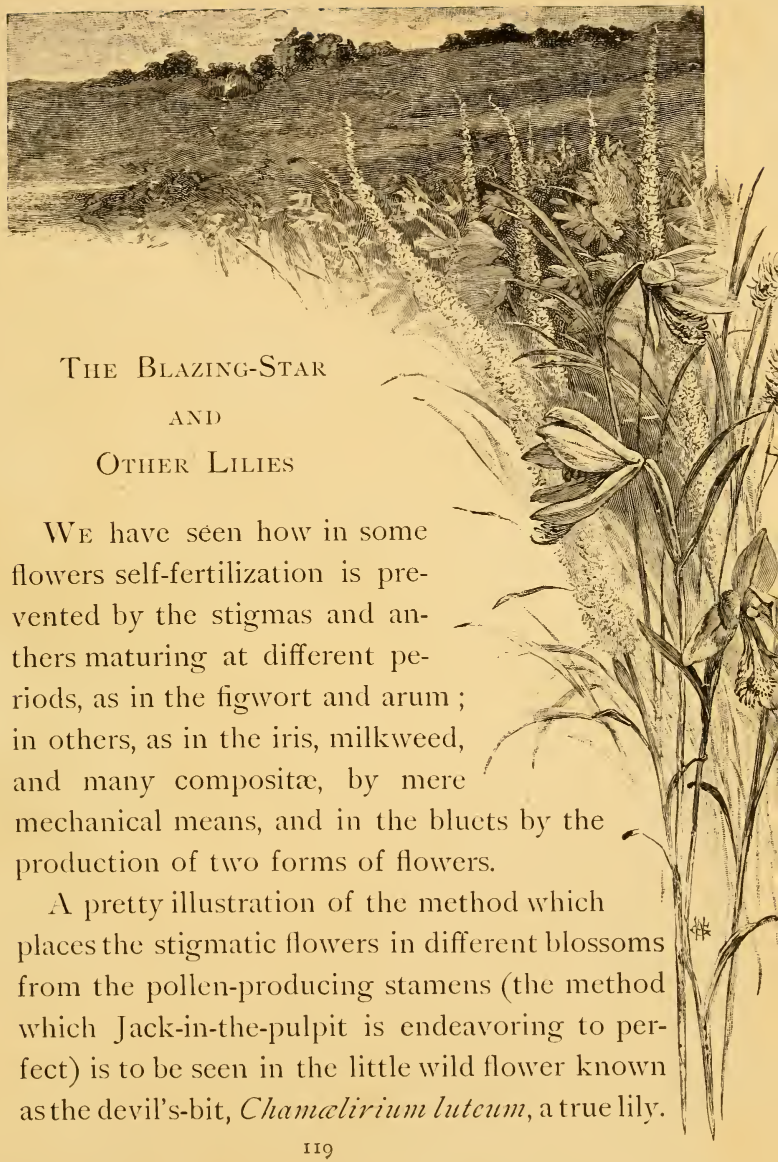
pollen to another flower. It will be seen that only the outer side of this appendage is stigmatic, and that it is thus naturally impossible for the blue-flag to self-fertilize—only one instance of thousands in which the anther and stigma, though placed in

the closest proximity, and apparently even in contact—seemingly with the *design* of self-fertilization—are actually more perfectly separated functionally than if in separate flowers, the insect alone consummating their affinity.

The blue-flag suffers constantly from the visits of pilferers, chiefly butterflies, which alight upon the drooping petals, and thrusting their long tongues through narrow openings between the lobes of the perianth, rifle the blossom of its sweets, without bestowing or receiving any pollen.

As the blue-flag grows in moist places, and consequently secretes an abundant supply of nectar, this robbery is not so serious a matter as it would be in the case of some other flowers.



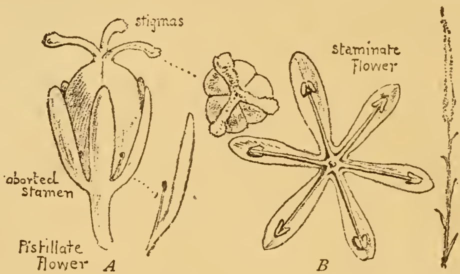


The Blazing-Star and Other Lilies

We have seen how in some flowers self-fertilization is prevented by the stigmas and anthers maturing at different periods, as in the figwort and arum; in others, as in the iris, milkweed, and many compositæ, by mere mechanical means, and in the bluets by the production of two forms of flowers.

A pretty illustration of the method which places the stigmatic flowers in different blossoms from the pollen-producing stamens (the method which Jack-in-the-pulpit is endeavoring to perfect) is to be seen in the little wild flower known as the devil's-bit, *Chamælirium luteum*, a true lily.

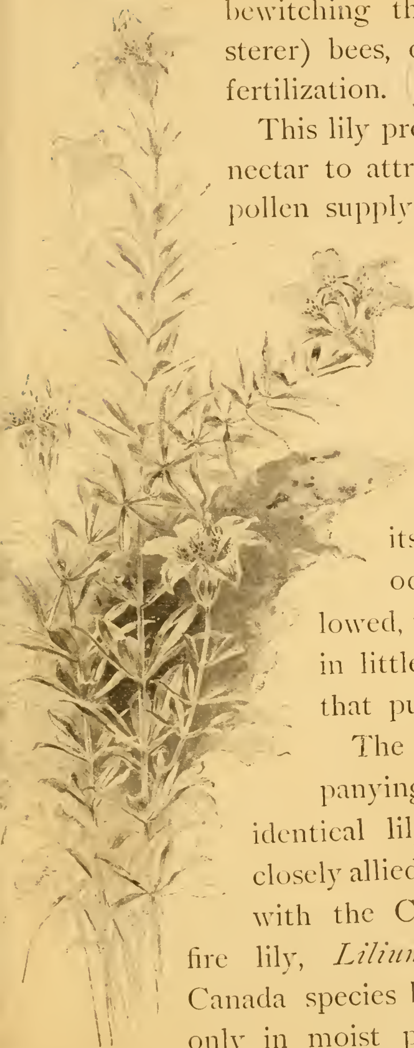
Its long, white, tapering spire of feathery bloom may often be seen rising above the sedges in the swamp. Two years ago I chanced upon a little colony of four or five plants at the edge of a bog. The flowers, all of them, were mere petals and stamens (like B of the figure). I looked in vain for a single stigmatic plant or flower; but far across the swamp, a thousand feet distant, I at length discovered a single spire, composed entirely of pistillate



flowers, as shown at A, and my magnifying-glass clearly revealed the pollen upon their stigmas—doubtless a welcome message brought from the isolated affinity afar by some winged sponsor, to whom the peculiar fragrance of the flower offers a special attraction, and thus to whom the fortunes of the devil's-bit have been committed.

THE CANADA LILY AND ITS COUSINS

The gorgeous Canada lily, *Lilium Canadense*, flaunts its spotted yellow petals in the hope of



bewitching the leaf-cutter (or upholsterer) bees, on which it depends for fertilization.

This lily produces pollen as well as nectar to attract its insect visitors, its pollen supply greatly exceeding what is necessary for its own perpetuation. This pollen serves the upholsterer bee as food for its young. The leaf-cutter stores the pollen between the long hairs on its breast—a different method from that usually followed, most bees storing pollen in little baskets, developed, for that purpose, on their hind legs.

The lily pictured in the accompanying illustration is not the identical lily here described, but a closely allied species often confounded with the Canada lily — namely, the fire lily, *Lilium Philadelphicum*. The Canada species bows its head and dwells only in moist places, while the fire lily stands erect and can live in very dry soil.

In strong contrast to the gay, pollen-loaded Canada lily is the pure white, sweetly scented Bermuda or Easter lily, *Lilium Harrisi.* Lubbock says, "There is not a hair or a line, not a spot or a color, for which there is not a reason—which has not a purpose or a meaning in the economy of Nature." If this be true, what do the variations in these near cousins signify?

The answer to our question is not far to seek. The Canada lily desires the services of an insect that flies by day and that is a pollen-gatherer rather than a nectar-lover. Its vivid yellow tints are, therefore, all sufficient, making the flower most conspicuous and suggesting the character of the reward which it will bestow upon its guests in return for their courteous attendance.

The Bermuda lily, on the contrary, wishes to avail itself of the kind offices of a moth which flies only during the twilight hours and which is a honey-tippler, caring nothing for pollen, since its eggs are deposited on the plants that feed its young. This lily, therefore, dons a white robe, which is more easily distinguished at dusk than any color, and as a further guide to its whereabouts and a hint of the sweets which it has to offer, it has acquired an extraordinary perfume.

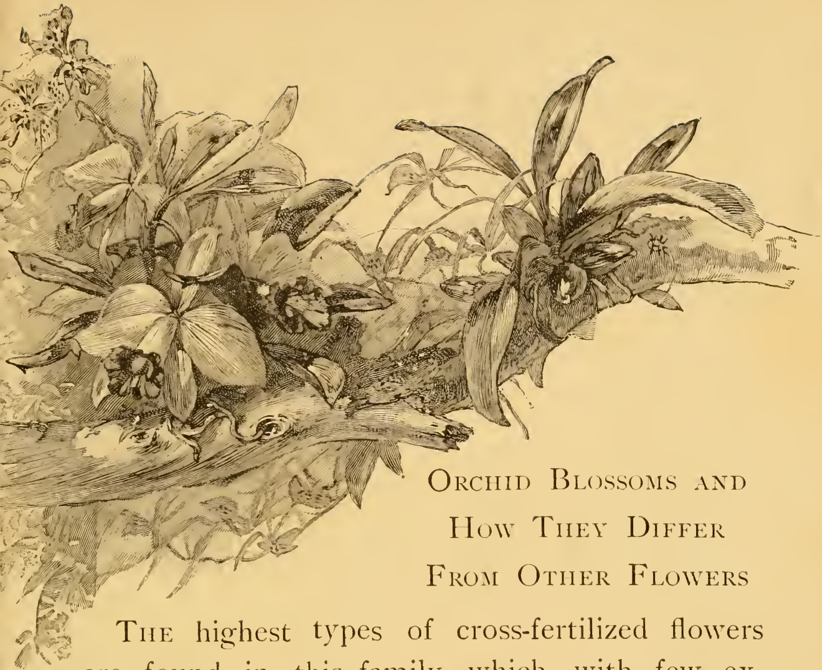
THE DOG-TOOTH VIOLET

The dainty little trout lilies, better known as "dog-tooth violets," or "yellow adder's tongues," are among the first spring blossoms, blooming before the foliage is dense enough to shut out their beloved sunlight, which they are always turning on their stalks to follow. At night they fold their petals and sleep to avoid the darkness.

The drooping position of the bells compels the small butterflies and bees that befriend these violets to cling so closely to the style and stamens to avoid falling, while they sip their nectar, that they cannot fail both to receive and bestow pollen. It serves another purpose also, protecting the flowers from thievish ants, who are always thirsty for honey, but incapable of making the blossoms any return for their sweets. Even though they succeed in ascending the slippery stalk, they are sure to get a tumble when they try to round the curve to reach the flower itself.

Thus all the wonderful and fascinating attributes of the Lily family have been evolved, not merely to add to their beauty, but in obedience to the same law of co-operation that governs the rest of the plant world. As Henry Drummond says: "The loveliness, the variegations of shade and tint, the

ornamentations, the scents, the shapes, the sizes of flowers, are all the gifts of co-operation. The flower in every detail is a monument to the co-operative principle."



Orchid Blossoms and How They Differ From Other Flowers

The highest types of cross-fertilized flowers are found in this family, which, with few exceptions, has utterly lost, like the milkweed and clover, the power of self-fertilization. What startling disclosures are revealed to the inward eye within the hearts of all these strange orchidaceous flowers! Blossoms whose functions, through long eras of adaptation, have gradually shaped themselves to the forms of certain chosen insect sponsors; blossoms whose chalices are literally fashioned to bees or butterflies; blossoms whose slender, prolonged nectaries invite and reward the murmuring sphinx-moth alone, the floral throat closely embracing his head while it

attaches its pollen masses to the bulging eyes, or perchance to the capillary tongue! And thus in endless modifications, evidences all of the same deep vital purpose.

And what is an orchid? How are we to know that this blossom which we plucked is an orchid? The average reader will exclaim, "Because it is an air-plant"—the essential requisite, it would seem, in the popular mind. Of over 3,000 known species of orchids, it is true a great majority are air-plants, or epiphytes—growing upon trees and other plants, obtaining their sustenance from the air, and not truly parasitic; but of the fifty-odd species of the northeastern United States, not one is of this character, all growing in the ground, like other plants. It is only by the botanical structure of the flowers that the orchid may be distinguished, the epiphytic character being of little significance botanically.

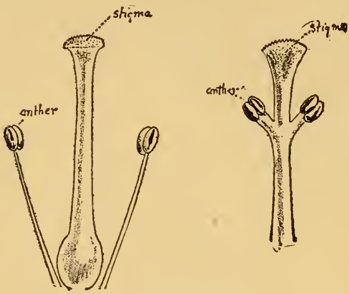


FIG. 1.

A brief glance at this structural peculiarity may properly precede our more elaborate consideration of a few species of these remarkable flowers.

The orchids are usually very irregular, and six-parted. The ovary is one-celled, and becomes a pod containing an enormous yield of minute, spore-like seeds (Fig. 3) in some species, as in the vanilla pod, to the number of a million, and in one species of the maxillaria, it has been computed, 1,750,000.

The pollen, unlike ordinary flowers, is gathered together in waxy masses of varying consistency, variously formed and disposed in the blossom, its

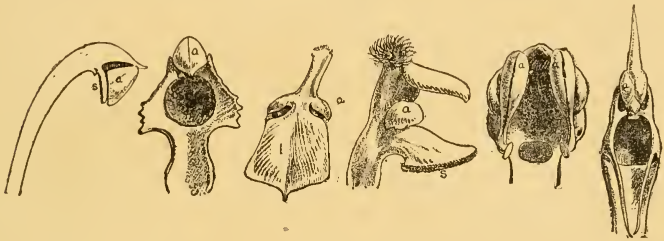


FIG. 2.

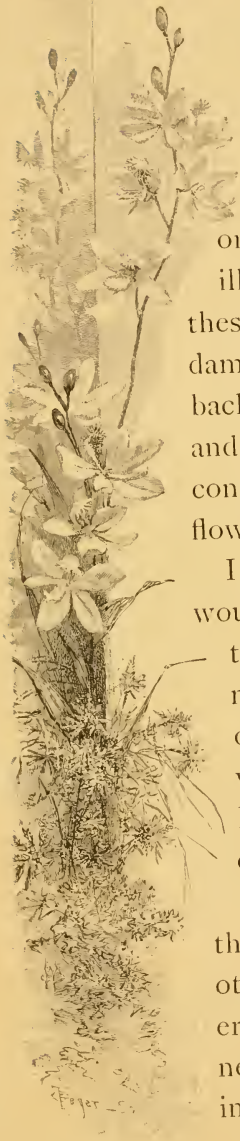
grains being connected with elastic cobwebby threads, which occasionally permit the entire mass to be stretched to four or five times its length, and recover its original shape when released. This is specially noticeable in the showy orchid, later described. The grains thus united are readily disentangled from their mass when brought into contact with a viscid object, as the stigma.

But the most significant botanical contrast and distinction is found in the union of the style and

stamens in one organ, called the column (Fig. 2), the stigma and the pollen being thus disposed upon a single common stalk. The contrast to the ordinary flower will be readily appreciated by a comparison of the diagrams of Fig. 1.

Fig. 3.

When, therefore, we find a blossom with the anthers or pollen receptacle united to a stalk upon which the stigma is also placed, we have an orchid.



The Showy Orchid

A group of the beautiful showy orchids is shown in my full-page illustration. A favorite haunt for these choice blossoms is the dark, damp, hemlock woods. Against this background their deep pink hoods and pure white lips stand out most conspicuously, justifying fully the flower's specific name of "spectabilis."

In the showy orchid we have what would appear a clear adaptation to the head of a bee, though one which might also avail of the service of an occasional butterfly. An enlarged view of the blossom is seen in Fig. 1, and in Fig. 2 a still greater enlargement of the column.

I have seen many specimens with the pollen masses withdrawn, and others with their stigmas well covered with the grains. Though I have never seen an insect at work upon it in its haunt, the whole form of the

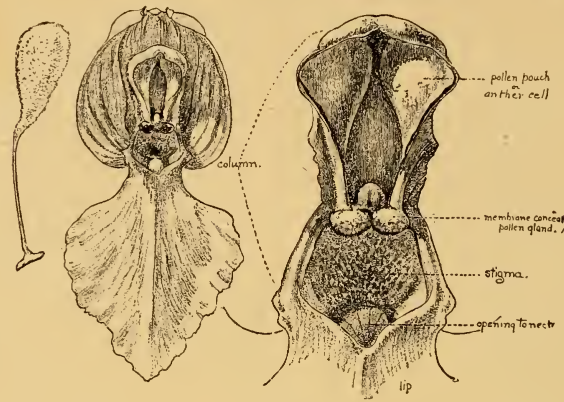


FIG. 1.

opening of the flower would seem to imply a bee, particularly a bumblebee. If we insert the point of a lead-pencil into this opening, thus imitating the entrance of a bee, its bevelled surface comes in contact with the viscid disks by the rupture of a veil of membrane, which has hitherto protected them. The disks adhere to the pencil, and are withdrawn upon it (Fig. 3). At first in upright position, as at A, they soon assume a forward

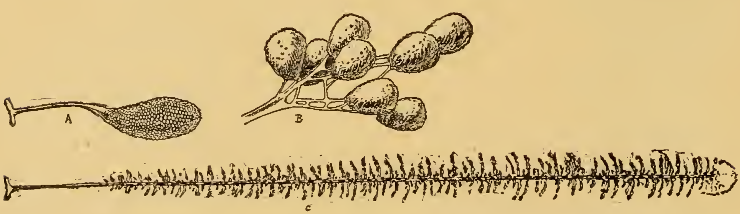


FIG. 2.

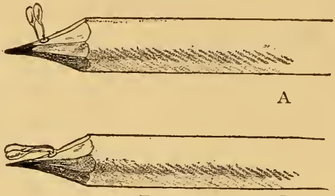


FIG. 3.

inclination, as shown at B. The nectary is about the length of a bumblebee's tongue, and is, moreover, so amply expanded at the throat below the stigma as to comfortably admit its wedge-shaped head. The three progressive diagrams (Fig. 4) indicate the result in the event of such a visit.

The pollen disks are here very close together, and are protected within a membranous cup, in which they sit as in a socket. As the insect inserts his head at the opening (A), it is brought against this

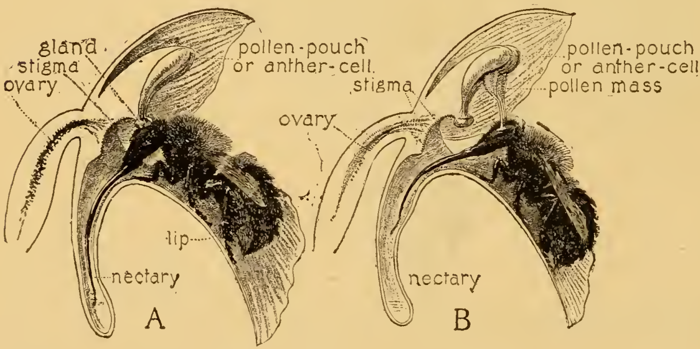


FIG. 4.

tender membrane, which ruptures and exposes the viscid glands of the pollen masses, which become instantly attached to the face or head, perhaps the eyes, of the burly visitor. As the insect retreats from the flower, one or both of the pollinia are withdrawn, as at B. Then immediately follows a downward movement, which exactly anticipates the position of the stigma, and as the bee enters the next flower the pollen clubs are forced against it (C).

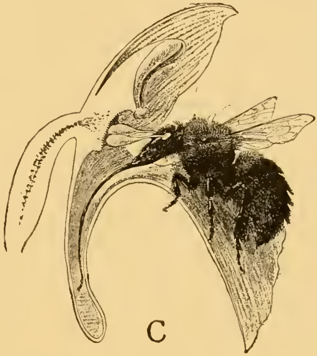


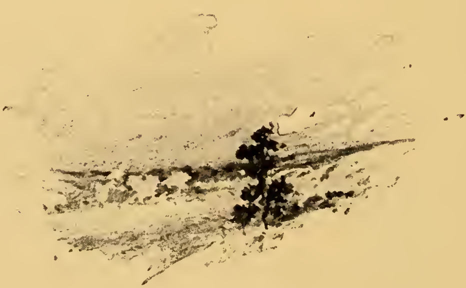
Fig. 4.

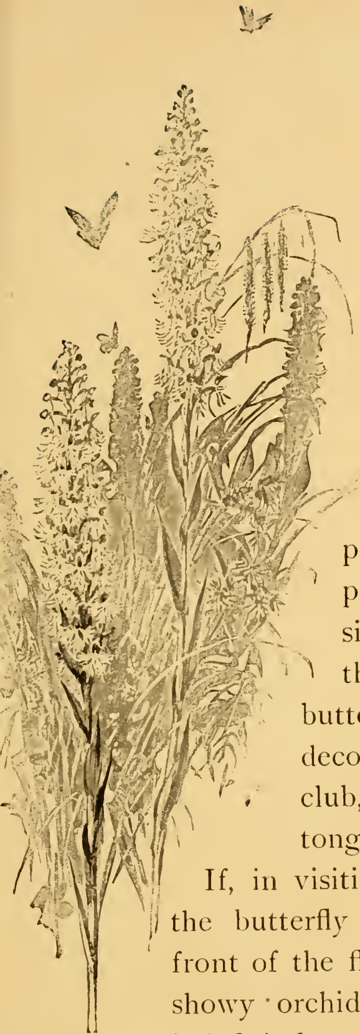
In the case of a smaller bee visiting the flower, the insect would find it necessary to creep farther into the opening, and thus might bring its thorax against the pollen-glands. In either case the change of position in the pollinia would insure the same result.

The entrance to the showy orchid's nectary is so formed as to insure the approach of the insect from the front—the only way in which the desired result can be accomplished. This direct approach, so necessary in many orchids, is insured by various devices—by the position of the lip upon which the

insect must alight; by the narrowed entrance of the throat of the flower in front of the nectary; by a fissure in the centre of the lip, by which the tongue is conducted, etc.

In other species allied to the above we find adaptations to the thorax, the eyes, and the face of the intended visitor; and there is still another group whose structure is distinctly adjusted to the *tongues* of insects—adaptations not merely of position of pollen masses, but even to the extent of a special modification in the entrance to the flower and the shape of the sticky gland, by which it may more securely adhere to that sipping member.





The Purple-Fringed and the Ragged Orchid

In the common pretty purple-fringed orchid, *H. psycodes*, whose dense cylindrical spikes of plumy blossoms occasionally empurple whole marshes, the pollen is tucked away in two parallel pouches, one on either side of the stigma (Fig. 1). In this case the eyes of sipping butterflies occasionally get their decoration of a tiny golden pollen club, but more frequently their tongues.

If, in visiting the purple-fringed orchid, the butterfly should approach directly in front of the flower, as the bee does in the showy orchid, he might sip the nectar indefinitely and withdraw his tongue without bringing it in contact with the viscid pollen disks. But in the dense crowding of the flowers,

over which the insect flutters indiscriminately, the approach is oftenest made obliquely, and thus the tongue brushes the disk on the side approached, and the pollen mass is withdrawn. But an examination

FIG. 1.

of this orchid affords no pronounced evidence of any specific intention. There is no unmistakable sign to demonstrate which approach is preferred by the flower, and this dependence on the insect's tongue or eye would seem to be left to chance.

In another kindred species, however, we have a distinct provision which insures the proper approach of the tongue—one of many similar devices by which the tongue is conducted directly to one or other of the pollen disks.

THE RAGGED ORCHID

This is the ragged orchid, *H. lacera*, a blossom far less fortunate in its attributes of beauty than the foregoing member of the family; its long, scattered spike of greenish white flowers being so inconspicuous in its grassy haunt as often to conceal the fact of its frequency. The initial illustration represents a group of these blossoms and an

individual flower is shown enlarged at Fig. 2, the lip here cut with a lacerated fringe. The pollen-pouches approach slightly at the base, directly opposite the nectary, where the two viscid pollen-glands stand on guard. Now, were the opening of the nectary at this point unimpeded, the same condition would exist as in the purple-fringed orchid—the tongue might be inserted between the pollen disks and withdrawn without touching them. But here comes the remarkable and very exceptional provision to make this contact a certainty—a suggestive structural feature of this flower, of which I am surprised to find no mention, either in our botanies or in the literature of cross-fertilization, so far as I am familiar with its bibliography. The nectary here, instead of being freely open, as in other orchids described, is abruptly closed at the central portion by a firm protuberance or palate, which projects downward from the base of the stigma, and closely meets the lip below.

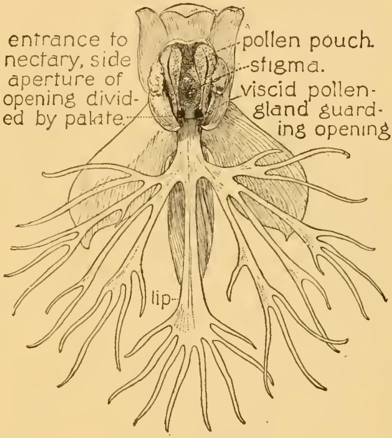


FIG. 2.

The throat of the nectary, thus centrally divided, presents two small lateral openings, each of which, from the line of approach through the much-narrowed entrance of the flowers, is thus brought directly beneath the waiting disk upon the same side. The structure is easily understood from the two diagrams, Figs. 2 and 3, both of which are indexed.

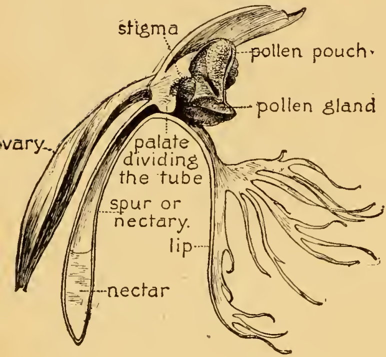


FIG. 3.

The viscid pollen-gland is here very peculiarly formed, elongated and pointed at each end, and it is not until we witness the act of its removal on the tongue of the butterfly that we can fully appreciate its significance.

I have often seen butterflies at work upon this orchid, and have observed their tongues generously decorated with the glands and remnants of the pollen masses.

The series of diagrams (Fig. 4) will, I think, fully demonstrate how this blossom utilizes the butterfly. At A we see the insect sipping, its tongue now in contact with the elongated disk, which adheres to and clasps it. The withdrawal of

the tongue (B) removes the pollen from its pouch. At C it is seen entirely free and upright, from which position it quickly assumes the new attitude shown at D. As the tongue is now inserted into the subsequent blossom, this pollen mass is thrust against the stigma (E), and a few of the pollen grains are

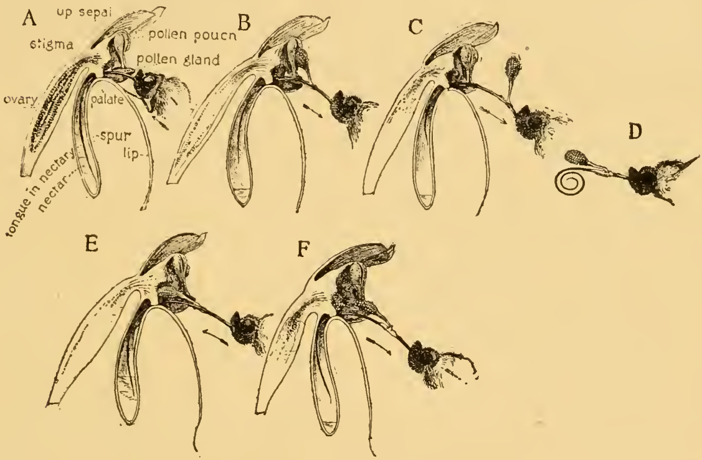


FIG. 4.

thus withheld upon its viscid surface as the insect departs (F).

Another similar device for assuring the necessary side approach is seen in the tubercled or small pale green orchis, *H. flava* (Fig. 5), a yellowish spiked species, more or less common in swamps and rich alluvial haunts.

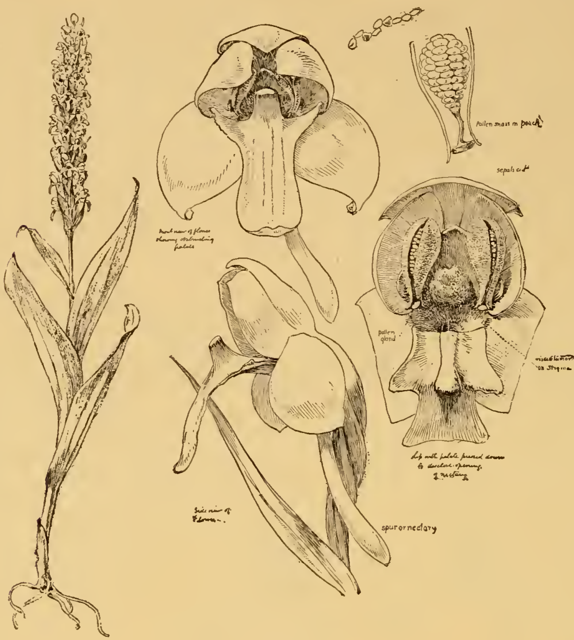
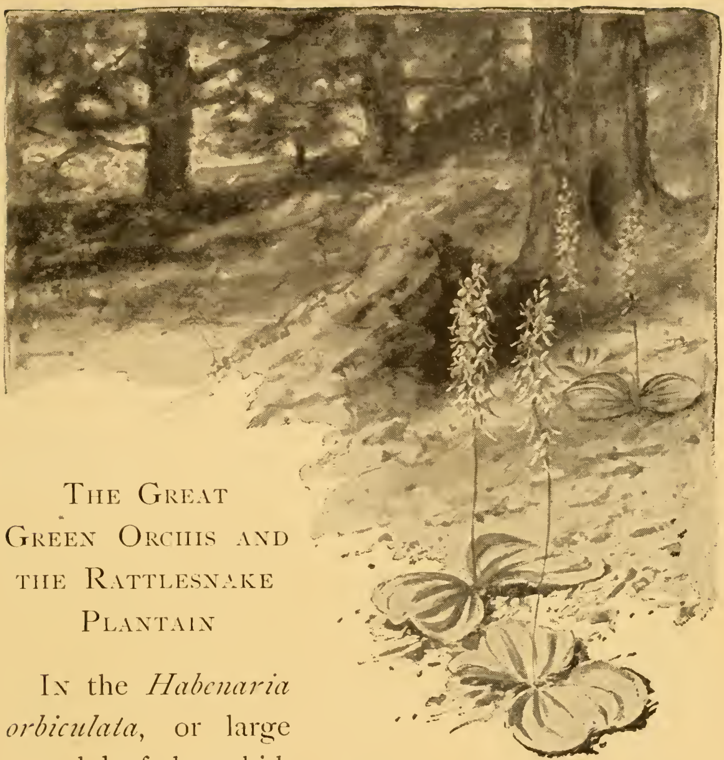


FIG. 5.

In the small pale green species this "tubercle," instead of depending from the throat, grows *upward* from the lip.

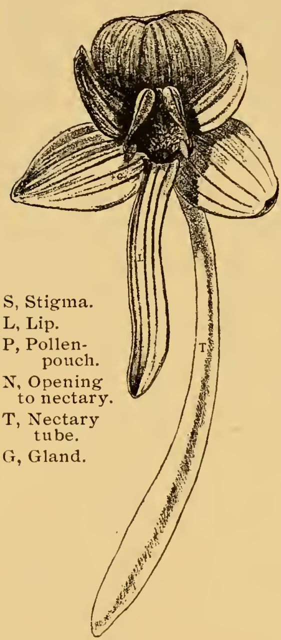


The Great Green Orchis and the Rattlesnake Plantain

In the *Habenaria orbiculata*, or large round-leafed orchid, sometimes called the great green orchis, we have a remarkable example of a form of floral construction which insures the transfer of the pollen on the eyes of the visiting insect. The structure and mechanism of this flower have been admirably described by Asa Gray.

All orchid-hunters know this most exceptional example of our local flora, and the thrill of delight experienced when one first encounters it in the

mountain wilderness, its typical haunt, is an event to date from—its two great, glistening, fluted leaves, sometimes as large as a dinner-plate, spreading flat upon the mould, and surmounted by the slender leafless stalk, with its terminal loose raceme of greenish-white bloom.



S, Stigma.
L, Lip.
P, Pollen-pouch.
N, Opening to nectary.
T, Nectary tube.
G, Gland.

FIG. 1.

A single blossom of the species is shown in Fig. 1, the parts indexed. The opening to the nectary is seen just below the stigmatic surface, the nectary itself being nearly two inches in length. The pollen is in two club-like bodies, each hidden within a fissured pouch on either side of the stigma, and coming to the surface at the base in their opposing sticky disks as shown. Many of the group Habenaria or Platanthera, to which this flower belongs, are similarly planned. But mark the peculiarly logical association of the parts here exhibited. The nectary implies a welcome to a tongue two inches long, and will reward none other. This clearly shuts out the

bees, butterflies, and smaller moths. What insect, then, is here implied? The sphinx-moth again, one of the lesser of the group. A larger individual might sip the nectar, it is true, but its longer tongue would reach the base of the tube without effecting the slightest contact with the pollen, which is of course the desideratum here embodied, and which has reference to a tongue corresponding to the length of the nectary. There are many of these smaller sphinxes. Let us suppose one to be hovering at the blossom's throat. Its slender capillary tongue enters the opening. Ere it can reach the sweets, the insect's head must be forced well into the throat of the blossom, where we now observe a most remarkable special provision, the space between the two pollen disks being exactly adjusted to the diameter of the insect's head.

What follows this entrance of the moth is plainly pictured in the progressive series of illustrations (Fig. 2). A represents the insect sipping; the sticky disks are brought in contact with the moth's eyes, to which they adhere, and by which they are withdrawn from their pouches as the moth departs (B). At this time they are in the upright position shown at C, but in a few seconds bend determinedly downward and slightly toward each

other to the position D. This change takes place as the moth is flitting from flower to flower. At E we see the moth with its tongue entering the nectary of a subsequent blossom. By the new position of the pollen clubs, they are now forced directly against the stigma (E). This surface is viscid, and as the insect leaves the blossom retains the grains in contact (F), which in turn withdraw others from the mass by means of the cobwebby threads by which the pollen grains are continuously attached. At G we see the orchid after the moth's visit—the stigma covered with pollen, and the flower thus cross-fertilized.

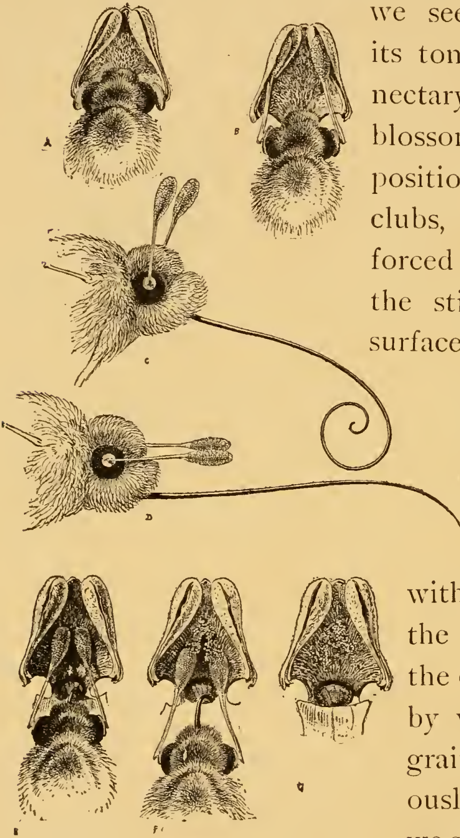


FIG. 2.

In effecting the cross-fertilization of one of the younger flowers, its eyes are again brought into contact with this second pair of disks, and these, with their pollen clubs, are in turn withdrawn, at length, perhaps, resulting in such a plastering of the insect's eyes as might seriously impair its vision, were it not fortunately of the compound sort.

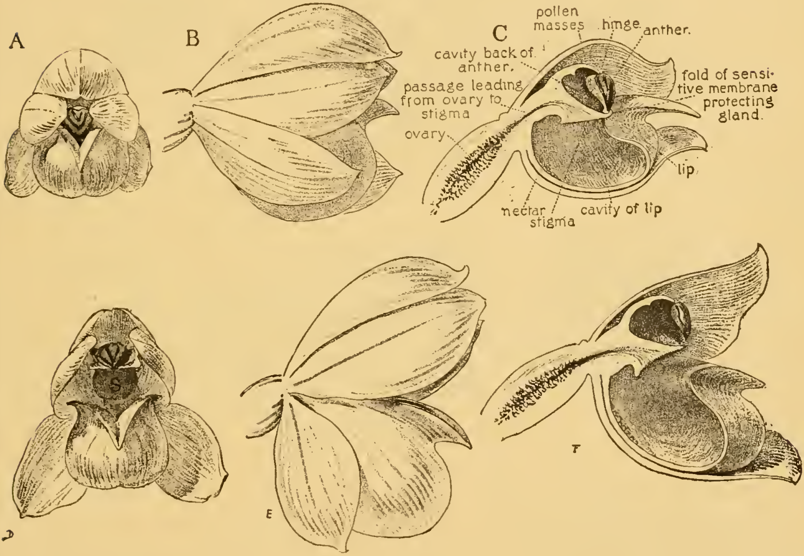


FIG. 3.

THE RATTLESNAKE-PLANTAIN

One of the most beautiful of our orchids, though its claims to admiration in this instance are chiefly confined to the foliage, is the common rattlesnake-

plantain, *Goodyera*, its prostrate rosettes of exquisitely white reticulated leaves carpeting many a nook in the shadows of the hemlocks, its dense spikes of yellowish-white blossoms signalling their welcome to the bees, and fully compensating in interest what they may lack in other attractive attributes.

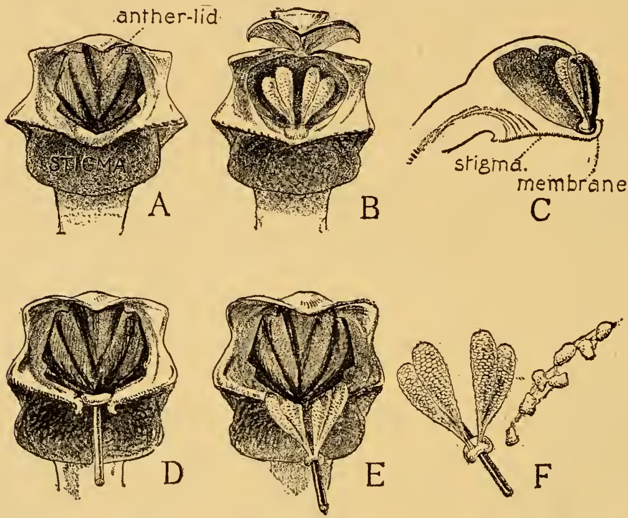


FIG. 4.

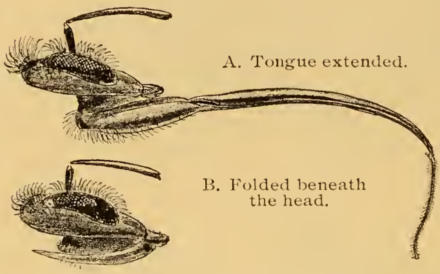
The single flower is shown enlarged in Fig. 3, A, a young blossom, with analyses B and C, the latter indexed; D, an older blossom, with similar analyses E and F. Both sorts are to be found upon every spike of bloom, as the inflorescence begins at the base and proceeds upward. As we look

into the more open flower, we observe a dark-colored speck, which, by analysis, proves to be the lid of the anther. This portion is further shown enlarged in Fig. 4, A. If we gently lift it with a pin, we disclose the pollen masses in the cavity B

FIG. 5.

thus opened (C, profile section), the two pairs united to a common viscid gland at the base, this gland again secreted behind a veil of moist membrane, as also shown at B. This membrane is, moreover, very sensitive to the touch. Below the flattened tip of

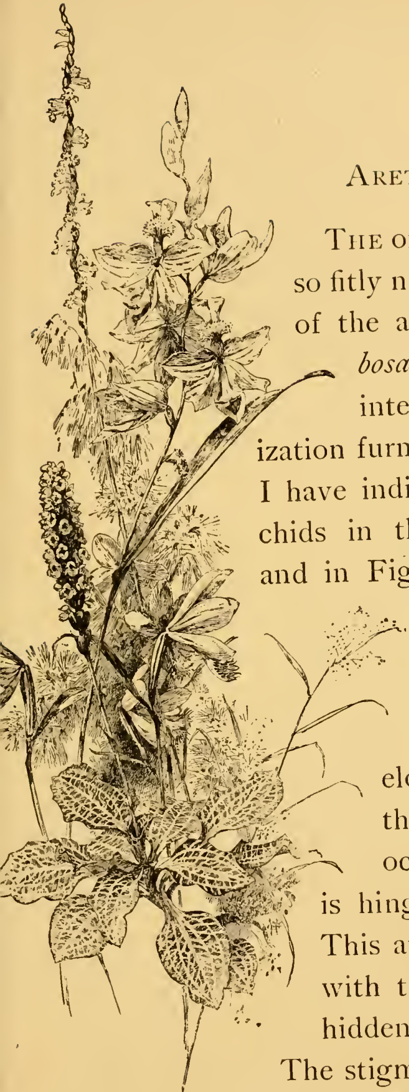
the column, and at a sharp inward angle, is the stigma. In the freshly opened flower (Fig. 3, A) the column inclines forward, bringing the anther low down, and its base directly opposite the V-shaped orifice in the lip, which also is quite firmly closed beneath the equally converging upper hood of the blossom. The entrance is thus much narrowed. If we insert a pin in this V-shaped entrance, it comes in contact with the sensitive membrane below the anther, and it is immediately ruptured, as shown at Fig. 4, D. The sticky gland is brought into immediate contact, and clasps the pin, which, now being withdrawn, brings away the pollen, as in E and F. Thus it is naturally removed on the tongue of its sipping bee.



The further demonstration will be better shown by profile sections (Fig. 5). Nectar is secreted in the hollow of the lip indicated, somewhat as in the cypripedium. If we now imitate with a probe the habit of the insect and the action of its tongue, we may witness a beautiful contrivance for cross-fertilization.

We will suppose the bee to be working at the top of the spike. He thrusts his tongue into the narrow opening (G). The membrane protecting the pollen-gland, thus surely touched, ruptures as described, and the exposed gland attaches itself to the tongue, being withdrawn as at H, and located on the insect's tongue, as in F, Fig. 4. The bee leaves this flower cluster and flies to another, upon which it will usually begin at the bottom. The flower thus first encountered is an old bloom, as in Fig. 3, D. Its sepals are more spreading, the lip slightly lowered, and the column so changed as to present the plane of the stigma in such a new position as to invariably receive the pollen. The tongue of a bee entering this flower conveys the pollen directly against the stigmatic surface (I), which retains its disentangled fecundating grains, as at J, and the flower's functional adaptations are fulfilled.

In the allied spiranthes, or lady's-tresses, a somewhat similar mechanism prevails.



Arethusa and Pogonia

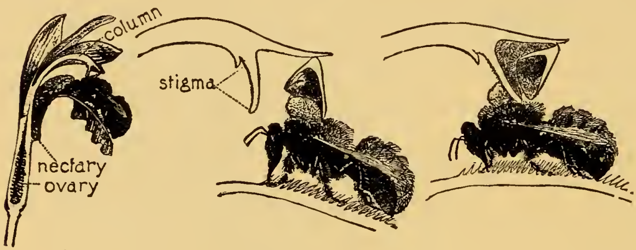
The orchid belle of our swamps, so fitly named for the water nymph of the ancients, Arethusa, *A. bulbosa*, presents one of the most interesting problems in fertilization furnished by our wild orchids. I have indicated a group of the orchids in their usual marshy haunt, and in Fig. 1, separately, a series of diagrams presents sections of the flower, natural size and duly indexed. The column is here quite elongated, forked at the tip, the space between the forks occupied by the anther, which is hinged to the upper division. This anther lid is closed tightly, with the sticky mass of pollen hidden behind it in the cavity. The stigma is on the external inner side of the lower division, and thus

distinctly separated from the pollen. The "lip" is extended forward as a hospitable threshold to the insect. And to what insect might we assume this invitation of color, fragrance, nectar, and threshold to be extended?

Let us consider the flower simply as a device to insure its own cross-fertilization. The insect is welcomed; it must alight and sip the nectar; in departing it must bear away this pollen upon its body, and convey it to the *next* Arethusa blossom which it visits, and leave it upon its stigma. The nectar is here secreted in a well—not very deep—and the depth of this nectar from the entrance is of great significance among all the flowers, having distinct reference to the length of the tongue which is expected to sip it. In the Arethusa, it is true, the butterfly or moth might sip at the throat of the flower, but the long tongues of these insects might permit the nectary to be drained without bringing their bodies in contact with the stigma. Smaller insects might creep into the nectary and sip without the intended fulfilment. It is clear that to neither of such visitors is the welcome extended. What, then, are the conditions embodied? The insect must have a tongue of such a length that, when in the act of

sipping, its head must pass beyond the anther well into the opening of the flower. Its body must be sufficiently large to come in contact with the anther. Such requisites are perfectly fulfilled by the bumblebee, and we may well hazard the prophecy that the Bombus is the welcomed affinity of the flower.

The diagrams (Fig. 1) sufficiently illustrate the



A B C

FIG. 1.

efficacy of the beautiful plan involved. At A the bee is seen sipping the nectar. His forward movement thus far to this point has only seemed to press the edge of the anther inward, and thus keep it even more effectually closed. As the bee retires (B), the backward motion opens the lid, and the sticky pollen is thus brought against the insect's back, where it adheres in a solid mass. He now flies to the next Arethusa blossom, enters it as before, and

in retiring slides his back against the receptive viscid stigma, which retains a portion of the pollen, and thus effects the cross-fertilization (C). Professor Gray surmised that the pollen was withdrawn on the insect's head, and it might be so withdrawn, but in other allied orchids of the tribe Arethusa, however, in which the structure is very similar, the pollen is deposited on the thorax, and such is probably the fact in this species. In either case, cross-fertilization would be effected. Nothing else is possible, and whether it is Bombus or not that effects it, the method is sufficiently evident.

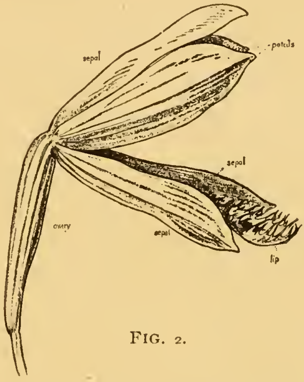


FIG. 2.

The sweet-pogonia, or grass-pink of our sedgy swamps (*Pogonia ophioglossoides*), a solitary rosy blossom, nodding on its slender stem above the grasses, is no less welcome an episode to the sauntering botanist than its cousin Arethusa. Its perfume, suggesting ripe red raspberries, is unique in the wild bouquet.

The bee as well as the botanist recognizes these flowers as closely akin, and visits the pogonia

with as much pleasure and profit as the Arethusa.

A profile view of the pogonia is shown in Fig. 2, its various parts indexed. Concealed behind the

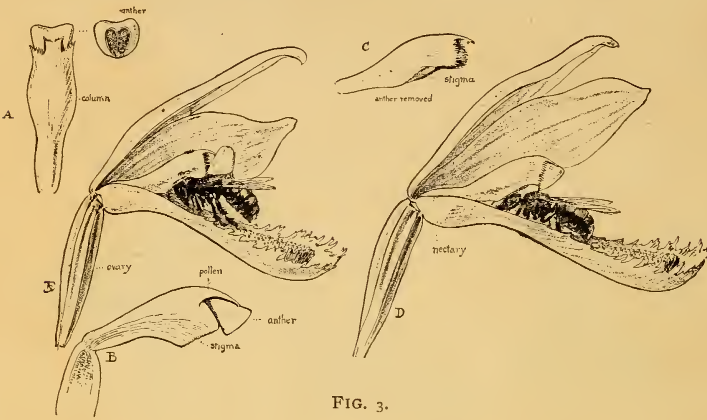


FIG. 3.

petals is the column indicated at A, Fig. 3. E and D, Fig. 3, illustrate the method of pollination, which is so nearly identical with that of Arethusa that further analysis seems superfluous.

The Moccasin-Flower

Of all our native orchids, at least in the northeastern United States, the cypripedium, or moccasin-flower, is perhaps the general favorite, and certainly the most widely known. This is readily accounted for not only by its frequency, but by its conspicuousness. The term "moccasin-flower" is applied more or less indiscriminately to all species. The flower is also known as the lady's-slipper, more specifically Venus's-slipper, as warranted by its generic botanical title, from a fancied resemblance in the form of the inflated lip, which is characteristic of the genus. We may readily infer that the fair goddess was not consulted at the christening. There are six native species of the cypripedium in this Eastern region, varying in shape and in color — shades of white, yellow,

crimson, and pink. The mechanism of their cross-fertilization is the same in all, with only slight modifications.

Our initial illustration shows the whtie species, but the most common of the group, the *C. acaule*, widely known as the moccasin-flower, whose large, nodding, pale crimson blooms we so irresistibly associate with the cool hemlock woods, will afford a better illustration of the general method of fertilization employed by the tribe.

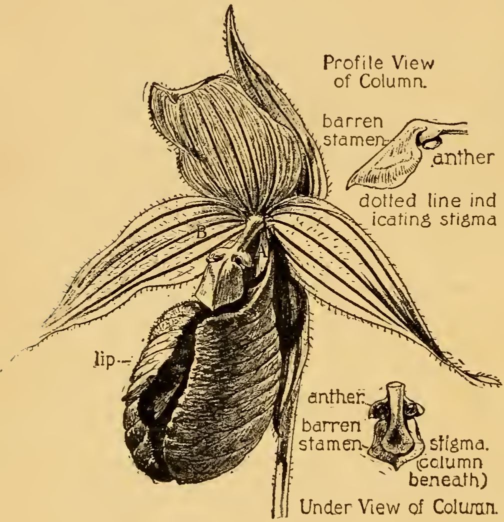


Fig. 1.

The lip in all the cypripediums is more or less sac-like and inflated. In the present species, *C. acaule*, however, we see a unique variation, this portion of the flower being conspicuously bag-like, and cleft by a fissure down its entire anterior face. In Fig. 1 is shown a front view of the blossom, showing this fissure. The "column" (B) in the cypripedium is very

distinctive, and from the front view is very non-committal. It is only as we see it in side section, or from beneath, that we fully comprehend the disposition of stigma and pollen. Upon the stalk of this column there appear from the front three lobes—two small ones at the sides, each of which hides an anther attached to its under face—the large terminal third lobe being, in truth, a barren rudiment of a former stamen, and which now over-arches the stigma. The relative position of these parts may be seen in the under view.

The anthers in this genus, then, are two, instead of the previous single anther with its two pollen-cells. The pollen is also quite different in its character, being here in the form of a pasty mass, whose entire exposed surface, as the anther opens, is coated with a very viscid gluten.

With the several figures illustrating the cross-fertilization, the reader will readily anticipate any description of the process, and only a brief commentary will be required in my text.

I have repeatedly examined the flowers of *C. acaule* in their haunts, have observed groups wherein every flower still retained its pollen, others where one or both pollen masses had been with-drawn, and in several instances associated with

them I have observed the inflated lip most outrageously bruised, torn, and battered, and occasionally perforated by a large hole. I had observed these facts in boyhood. The inference, of course, was that some insect had been guilty of the mutilation; but not until I read Darwin's description of the cross-fertilization of this species did I realize the full significance of these telltale evidences of the escape of the imprisoned insect. Since that time, many years ago, I have often sat long and patiently in the haunt of the cypripedium awaiting a natural demonstration of its cross-fertilization, but as yet no insect has rewarded my devotion.

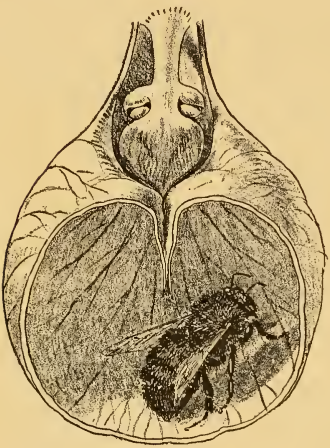


FIG. 2.

At length, in hopelessness of reward by such means, I determined to see the process by more prosaic methods. Gathering a cluster of the freshly opened flowers, which still retained their pollen, I took them to my studio. I then captured a bumblebee, and forcibly persuaded him to enact the demonstration which I had so long waited for

him peaceably to fulfil. Taking him by the wings, I pushed him into the fissure by which he is naturally supposed to enter without persuasion. He was soon within the sac, and the inflexed wings of

FIG. 3.

the margin had closed above him, as shown in section, Fig. 2. He is now enclosed in a luminous prison, and his buzzing protests are audible and his vehemence visible from the outside of the sac. Let us suppose that he at length has become reconciled

to his condition, and has determined to rationally fulfil the ideal of his environment, as he may, perhaps, have already done voluntarily before. The buzzing ceases, and our bee is now finding sweet solace for his incarceration in the copious nectar which he finds secreted among the fringy hairs in the upper narrowed portion of the flower, as shown at Fig. 3.

Having satiated his appetite, he concludes to quit his close quarters. After a few moments of more vehement futile struggling and buzzing, he at length espies, through the passage above the nectary fringe, a gleaming light, as from two windows (A). Toward these he now approaches. As he advances, the passage becomes narrower and narrower, until at length his back is brought against the overhanging stigma (Fig. 4). So narrow is the pass at this point that the efforts of the bee are distinctly manifest from the outside in the distension of the part and the consequent slight change in the droop of the lip. In another moment he has passed this ordeal, and his head is seen protruding from the window-like opening (A) on one side of the column. But his struggles are not yet ended, for his egress is still slightly checked by the narrow dimensions of the opening, and also by the detention of

the anther, which his thorax has now encountered. A strange etiquette this of the cypripedium, which speeds its parting guest with a sticky plaster smeared all over its back. As the insect works its way beneath the viscid contact, the anther is seen to be drawn outward upon its hinge, and its yellow contents are spread upon the insect's back (Fig. 5), verily like a plaster.

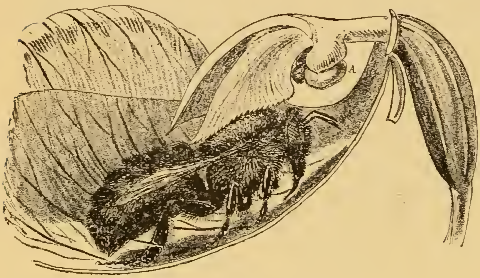


FIG. 4.

Catching our bee before he has a chance to escape with his generous floral compliments, we unceremoniously introduce him into another cypripedium blossom, to which, if he were more obliging, he would naturally fly. He loses no time in profiting by his past experience, and is quickly creeping the gauntlet, as it were, or braving the needle's eye of this narrow passage. His pollen-smeared back is soon crowding beneath the overhanging stigma again, whose forward-pointed papillæ scrape off a portion of it (Fig. 4), thus insuring the cross-fertilizing of the flower, the bee receiving a fresh effusion of cypripedium

compliments piled upon the first as he says "good-by." It is doubtful whether in his natural life he ever fully effaces the telltale effects of this demonstrative *au revoir*.

FIG. 5.

Such, with slight modifications, is the plan evolved by the whole cypripedium tribe. Darwin mentions bees as the implied fertilizers, and doubtless many of the smaller bees do effect cross-fertilization in the smaller species. But the more ample passage in acaule would suggest the medium-sized Bombus as better adapted.

The large yellow lady's-slipper or whip-poor-will's shoe, *C. hirsutum*, is fond of swampy woodlands. It has a peculiar, rather disagreeable, oily odor, which might lead one to suppose that flies fertilize it. Darwin, however, whom Professor Asa Gray interested in this species, found that small bees were more serviceable.

The smaller variety of the yellow lady's-slipper,

C. parviflorum, has a delightfully delicate fragrance; the coloring, too, is deeper than that of its congener. In all other respects, the two species are nearly identical.

Nature's Inexhaustible Treasures

The method of fertilization of each one of our fifty native orchids, though based upon one of the foregoing plans, affords its new surprise in its special modification in adaptation to its insect sponsor — all these various shapes, folds of petals, positions, colors, the size, length, and thickness of nectary, the relative positions of pollen and stigma, embodying an expression of welcome to the insect with which its life is so marvellously linked.

There are similar mysteries to those we have penetrated concealed within the hearts of many other of our most common wild flowers, and it is one of the most inspiring fascinations of Nature-study that, while rewarding her devotees with a full measure of her confidence, she still allures them on with an inexhaustible reserve. You may discover some unknown flower, dissect and analyze its parts, and find its place among the genera and species of vegetation; but there are strange testimonies beneath its conformation that are still unheeded, even as in

these curious orchids, known and classified long ere Darwin sought the secret of their wondrous forms.

We cannot all be scientists or explorers, but we can at least learn to lend an answering, intelligent welcome to those little faces that smile at us from among the grass and withered leaves, that crowd humbly about our feet, and are too often idly crushed beneath our heel. The darkest pathless forest is relieved of its gloom to him who can nod a greeting with every footstep; who knows the pale dicentra that nods to him in return; who can call by name the peeping lizard among the moss, the pale white pipe among the matted leaves, or even the covering mould among the damp débris.

And to him who knows the arcana beneath a stone; who has learned with reverence how the clover goes to sleep, how the fireweed spins its silken floss, or how the spider floats its web from tree to tree; who has seen the brilliant cassida, the palpitating gem upon the leaf, change from burnished gold to iridescent pearl, or has watched the wondrous resurrection of the imago bursting from its living tomb—to such a one there is in all the length and breadth of Nature no such thing as exile, no

such thought as loneliness and it were the voice of an unknown sentiment which should declare that

> "A primrose by a river's brim
> A yellow primrose was to him,
> And it was nothing more."

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SUPPLEMENT

The following tables give the botanical name, insect visitor, method, if any, of preventing or limiting self-fertilization,* and various other facts for about two hundred and fifty species of our native wild flowers. This matter is intended only to indicate the lines along which personal investigation may be carried on, as it is impossible with the scanty data at present available on this subject, to compile anything exhaustive or final. Gray's classification has been followed.

In supplying the information given under the head of "Insect Visitors," the object in view has been to give the insects best adapted to serve the needs of the flowers, not to give a complete list of all the insects that may at various times visit them. The names of the less important insects as well as their scientific names, where given, are enclosed in brackets.

* The later writers make a distinction between "fertilization" and "pollination." "Pollination" is used to signify the transfer of pollen from anther to stigma, while "fertilization" is understood to mean the union of the nucleus of the pollen grain with the nucleus of the ovule. This technical distinction, for various reasons, it has not been thought necessary to observe in the present volume, the terms being used interchangeably.

Crowfoot Family (*Ranunculàceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Virgin's Bower, or Virginia Clematis	Clématis Virginiàna	Flies and short-tongued bees	Stigmatic flowers generally separate from staminate flowers.
Liver-leaf, or Hepatica	Hepática triloba	Pollen-collecting bees and flies (beetles)	Some flowers perfect, others stigmatic, and others staminate. Perfect flowers frequently self-fertilized.
Sharp-lobed Hepatica	Hepática acutíloba	Bees and flies	Stigmatic flowers sometimes separate from staminate ones.
Windflower, or Wood Anemone	Anemòne nemoròsa	Bees, beetles, and flies	Self-fertilization probably quite frequent.
Tall Meadow Rue	Thalictrum çornuti	Many insects	Some flowers perfect, others staminate, others stigmatic.
Common Meadow Buttercup, or Tall Crowfoot	Ranúnculus acrís	60 species noted	
White Baneberry	Actæ̀a álba	Female bees (Halictus)	Tendency toward maturing stigma before anthers.
Black Cohosh, or Tall Bugbane	Cimicífuga racemòsa	Pollen-gathering flies	
Marsh Marigold, or Amer. Cowslip	Cáltha palústris	Bees and flies (beetles and butterflies)	Anthers open outward.
Gold-thread, or Canker Root	Cóptis trifòlia	Gnats and beetles	
Wild Columbine	Aquilègia Canadénsis	Bumblebees and hummingbirds	Anthers mature before stigma. Flower has lost the power of self-fertilization.
European, or Common Garden Columbine	Aquilègia vulgàris	Bumblebees, long-lipped bees, long-tongued bees	Some anthers mature before stigmas.
Field, or Branched Larkspur	Delphínium Consólida	Bumblebees and butterflies	Anthers mature and wither before stigmas are mature. Flower has lost power of self-fertilization.
Tall Wild Larkspur	Delphínium exaltàtum	Bumblebees	Anthers mature before stigma.

Magnolia Family (*Magnoliaceàe*)

Laurel, or Small Magnolia	Magnòlia glaùca	Beetles	Stigma matures before anthers.

Supplement

Barberry Family (*Berberidaceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Common Barberry	Berberis vulgàris	Bees (beetles and flies)	Pollen concealed in boxes, stamens liberated by the insect. Self-fertilization not probable. See text

Water-lily Family (*Nymphaeaceae*)

Yellow Nelumbo, or Water Chinquepin	Nelumbo lùteum	Small bees, flies, and beetles	Stigma matures before anthers
Sweet Scented White Water Lily or Pond Lily	Nymphaèa odoràta	Pollen-gathering bees and flies (beetles)	Self-fertilization possible
Large Yellow Pond or Water Lily	Nùphar ádvena	Small bees, flies, and beetles	Stigma matures before anthers

Poppy Family (*Papaveraceae*)

Blood root	Sanguinària Canadénsis	Short-tongued bees and flies	Stigma matures before anthers

Fumitory Family (*Fumariaceae*)

Dutchman's Breeches, or White Hearts	Dicéntra cucullària	Long-tongued female bumble-bees	Anthers mature before stigmas
Pale Corydalis	Corýdalis glaùca	Pollen-collecting bees, also bumble-bees seeking nectar	

Mustard Family (*Cruciferae*)

Field or Corn Mustard	Brassica Sinàpis arvénsis	Bees and flies	Anthers rotate away from stigma. Self-fertilization possible
Ladies' Smock, or Cuckoo-flower	Cardamìne praténsis	Many insects	Anthers rotate away from stigma. Self-fertilization possible
Bulbous, or Spring Cress	Cardamìne rhomboídea	Bees, flies, butterflies, etc. (Andrena and Halictus)	Stamens revolve away from stigma. Self-fertilization possible
Two-leaved Tooth-wort, or Crinkle-root	Dentària diphýlla	Pollen-collecting bees (Andrena and Halictus)	
Whitlow grass	Dràba vérna	Pollen-collecting bees	Self-fertilization very common
Shepherd's Purse	Capsella Bursa-pastòris	Flies (Syrphidæ and Muscidæ)	Self-fertilization very common

Supplement

Violet Family (*Violaceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Arrow-leaved Violet	Vìola sagittàta	Bees	Showy flowers cross fertilized. Depends largely for the propagation of its kind upon cleistogamous buds
Common Blue Violet	Vìola cucullàta	Small pollen-collecting bees (Osmias) (bumble-bees, butterflies)	Stigma remote from anther, but self-pollination possible
Early Blue Violet	Vìola palmàta	Bees and butterflies	Protruding stigma strikes incoming bee. Pollen liberated, by the jar of insect's contact with the stigma, from the anther
Bird-foot Violet	Vìola pedàta	Long-tongued bees and butterflies	
Sweet White Violet	Vìola blánda	Bees	
Primrose-leaved Violet	Vìola primulæfòlia	"	
Lance-leaved Violet	Vìola lanceolàta	"	
Canada Violet	Vìola Canadénsis	"	

Rock-rose Family (*Cistaceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Long-branched frostweed, or Frost flower	Heliánthemum Canadense	Many insects	Stamens lie flat to petals well away from stigma

St. John's-wort Family (*Hypericaceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Common St. John's Wort	Hypéricum perforàtum	Pollen-gathering bees. Pollen-eating flies (Beetles)	Self-fertilization very common
Marsh St. John's Wort	Elòdes Virgínica	Pollen-gathering bees. Pollen-eating flies (Beetles)	Self-fertilization very common

Pink Family (*Caryophyllaceae*)

Subdivision Chickweed Family

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Deptford Pink	Diánthus Armèria	Butterflies	Self-pollination probable
Corn-cockle	Lýchnis Githàgo	Moths, bees, flies, butterflies	Anthers mature before stigma
Wild or Pink Catchfly	Silène Pennsylvánica	Bees, butterflies	Anthers mature before stigmas, 2 sets of stamens maturing at different intervals, 3 styles
Fire Pink	Silène Virgínica	Butterflies	

Pink Family—*Continued*

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Starry Campion	Silène stellàta	Moths and butterflies	
Bladder Campion	Silène inflàta	Moths	Some flowers perfect, others staminate, and others stigmatic; still others mature anthers and stigmas at different periods
Soapwort, or Bouncing Bet	Saponària officinàlis	Sphinx Moth Pollen-gathering bees	Anthers mature before stigmas, 2 sets of stamens maturing at different intervals
Common Chickweed	Stellària mèdia	Small bees and flies	Has not lost the power of self-fertilization, though its anthers generally mature before its stigma

Purslane Family (*Portulacaceae*)

Spring Beauty	Claytònia Virgínica	Female bumblebees (flies, butterflies)	Anthers mature before stigma

Mallow Family (*Malvaceae*)

Swamp Rose Mallow	Hibíscus Moscheùtos	Bumblebees	Anthers mature before stigma
Common or Round-leaved Mallow	Málva rotundi-fòlia	Mainly bees	Self-fertilization very common
High Mallow	Málva sylvéstris	Many insects	Pistils radiate away from stamens. Stamens mature first

Geranium Family (*Geraniaceae*)

Yellow Wood Sorrel	Óxalis stricta	Bees	Self-pollination usual
White or True Wood Sorrel	Óxalis Acetosélla	Few insects	Showy flowers incapable of self-fertilization. Produces also cleistogamous buds
Violet Wood Sorrel	Óxalis violacea	Small bees	Dimorphic blossoms
Wild or Spotted Geranium or Cranes bill	Gerànium maculàtum	Bees	Anthers mature before stigma
Herb Robert or Red Robin	Gerànium Robertiànum	Flies	Anthers mature before stigma. Two sets of stamens. Evil-smelling flower
Spotted Touch-me-not or Jewel weed	Impàtiens fúlva	Bees, humming birds	Stigma concealed beneath stamens. Anthers mature first. Produces also cleistogamous buds

Supplement

Cashew Family (*Anacardiaceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Staghorn Sumac	Rhús týphina	Short-tongued bees and flies	Stigmatic flowers generally separate from staminate ones

Staff-tree Family (*Celastraceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Climbing Bitter-sweet	celástrus scándens	Small bees and flies	Stigmatic flowers generally separate from staminate ones

Polygala Family (*Polygalaceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Common Field or Purple Milkwort	Polýgala sanguínea	Bees	Fruiting organs within a tube split on the back to insure contact with bee
Racemed Milkwort	Polýgala polygama	Bees	Produces both showy and cleistogamous buds
Fringed Polygala	Polýgala paucifòlia	Bumblebees	Stamens and pistils are enclosed in keel, the two surfaces, however, turned in opposite directions. Produces also cleistogamous buds

Pulse Family (*Leguminosae*)

NOTE.—As a family the peas follow the plan of concealing both anthers and stigmas within a keel. When these organs are released by the pressure of the insect the stigma strikes the visitor first, thus receiving pollen from another flower before its own is bestowed upon its benefactor.

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Wild Lupine	Lupìnus perénnis	Long-lipped pollen-collecting bees	
Rattle box	Crotalària sagittàlis	Bees	
White Sweet Clover	Melilòtus alba	Short-tongued bees	
Red Clover	Trifòlium praténse	Bumblebees, butterflies (hummingbirds)	
Trailing Bush Clover	Lespedèza procúmbens	Bees	Produces also cleistogamous buds
Canadian or Showy Tick-trefoil	Desmòdium Canadénse	Pollen-collecting bees (bumblebees, chiefly)	
Ground-nut, or Wild Bean	Ápios tuberòsa	Butterflies and long-tongued bees	Pulp between anthers and stigma. Produces also cleistogamous buds
Hog-Peanut	Amphicarpæa monòica	Bees	Produces also cleistogamous buds
Butterfly Pea	Clitòria Mariàna	Bees	
Beach Pea	Láthyrus marítimus	Long-tongued bees	Self-pollination probable

Pulse Family—*Continued*

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Blue, Tufted or Cow Vetch	Vícia Crácca	Flies, butterflies, bees	Self-fertilization usual
Wild False Indigo	Baptisia tinctòria	Bees	
Wild Senna	Cássia Marilándica	Bumblebees	
Small Flowering Senna	Cássia níctitans	Pollen-gathering bumblebees	Anthers radiate away from stigma

Rose Family (*Rosaceae*)

Note.—Roses as a family are apt to mature their anthers and stigmas simultaneously, but the former are usually turned outward, so that the insect visitor may strike the stigma first.

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Meadow-sweet	Spiræ̀a salicifòlia	Small bees (Andrenidæ and Syrphidæ) and beetles	Stigma generally matures before anthers, though self-fertilization is not infrequent
Nine-bark	Spiræ̀a opulifòlia	Bees and flies	
Hard hack, or Steeplebush	Spiræ̀a tomentòsa	Pollen-collecting bees	Self-fertilization very common
Goats-beard	Spiræ̀a Arúncus	Bees, flies, and beetles	Some flowers perfect, others staminate, and others stigmatic
Queen-of-the Prairie	Spiræ̀a lobàta	Butterflies and bees	
Indian Physic, or American Ipecac	Gillènia trifoliàta	Small long-tongued bees	
Purple or Water Avens	Geum rivàle	Bumblebees	Stigmas generally mature before anthers
White Avens	Gèum álbum	Bees and flies	Stigmas mature before anthers
Virginia Strawberry	Fragària Virginiàna	Several insects	Stigmatic flowers frequently separate from staminate flowers
Creeping Dalibarda	Dalibárda rèpens		Produces both showy and cleistogamous buds
Purple flowering, or Virginia Raspberry	Rùbus odoràtus	Several insects, no special visitor Bumblebees	Outer anthers mature a little before stigmas, but self-fertilization from the inner row of anthers is common
Wild Red Raspberry	Rùbus strigòsus	Pollen-collecting bees	Self-fertilization very common
High Blackberry	Rùbus villòsus	Bumblebees	Stigma generally matures a little before anthers. Stamens turn away from stigma. Self-fertilization not uncommon.

Rose Family—*Continued*

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Common Agrimony	Agrimònia Eupatòria	Flies and bees	Self-fertilization usual
Common Hawthorn	Cratægus coccínea	Flies and beetles	Stigma matures before anthers
June Berry	Amelánchier Canadénsis	Female bees	Self-fertilization probable

Saxifrage Family (*Saxifragàceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Grass of Parnassus	Parnássia Caroliniàna	Flies and bees	Anthers mature before stigma
Early Saxifrage	Saxífraga Virginiénsis	Flies and bees	Anthers mature before stigma
False Mitrewort	Tiarélla Cordifòlia	Bees	

Orpine Family (*Crassulàceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Orpine, or Live-forever	Sédum Teléphium	Bees and flies	Anthers mature before stigma

Witch-Hazel Family (*Hamamelaceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Witch-Hazel	Hamamèlis Virginica	Bees and flies	Stigmatic flowers generally separate from staminate flowers

Evening-Primrose Family (*Onagràceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Enchanter's Nightshade	Circæa Lutetiàna	Bees and flies	Stigma a landing place for incoming insects. Self-fertilization infrequent
Great Willow-herb or Fireweed	Epilòbium angustifòlium	Bumblebees	Anthers mature before stigma
Evening Primrose	Œnothèra biénnis	Moths (bumblebees, humming birds)	Anthers mature before stigma
Common Sundrop	Œnothèro fructicòsa	Bumblebees and butterflies	Stigmas protrude far beyond anthers. Self-fertilization impossible

Melàstoma Family (*Melastomàceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Meadow-Beauty, or Deer-Grass	Rhéxia Virgínica	Bees	

Loosestrife Family (*Lythràceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Spiked Loosestrife	Lýthrum Salicària	Butterflies and bees (flies)	Trimorphic

Cactus Family (*Cactàceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Common Prickly-Pear	Opúntia vulgàris	Flies, bees, beetles	Self-fertilization usual

Supplement

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Gourd Family (*Cucurbitàceae*)			
Star-Cucumber	Sicyos angulatus	Several insects, no special visitor	Stigmatic flowers separate from staminate flowers
Parsley Family (*Umbellíferae*)			
Black Snake-root	Saníeula Maryländica	Several insects, no special visitor	Stigmas mature before anthers, which are imprisoned beneath the petals until all danger of self-fertilization is past. Some flowers perfect, others staminate only
Common Carrot	Daûcus Caròta	Bees, wasps, flies, beetles, etc.	Stigmatic flowers on outer edge. Staminate flowers grouped in center
Sweet Cicely	Osmorrhìza longístylis	Flies and bees	Some flowers perfect, others staminate. In the perfect flowers the anthers mature before the stigmas
Water Hemlock, or Spotted Cowbane	Cicûta maculàta	Flies, bees, and wasps	Some perfect, others staminate flowers. Perfect flowers mature anthers before stigmas
Cow-Parsnip	Heraclèum lanàtum	Flies, bees, and wasps	Anthers mature before stigmas
Ginseng Family (*Aralíàceae*)			
Spikenard	Aràlia racemòsa	Chiefly flies and bees	Some flowers perfect, others staminate, others stigmatic
Common Wild Sarsaparilla	Aràlia nudicaûlis	Flies and bees	
Ginseng	Aràlia quinquefòlia	Several insects, no special visitor	Bears both showy and cleistogamous flowers
Dogwood Family (*Cornàceae*)			
Flowering Dogwood	Córnus flórida	Bees, flies, and butterflies	Self-fertilization possible
Honeysuckle Family (*Caprifoliàceae*)			
Twin-flower	Linnæ̀a boreàlis	Bees and flies	Stigma protrudes, in advance of anthers
Coral or Trumpet Honeysuckle	Lonícera sempèrvirens	Humming birds	
Sweet Wild Honeysuckle	Lonicera gràta	Sphinx moth	Stigma protrudes and receives incoming bee
Bush Honeysuckle	Dierv̀illa trífida	Bees	Stigma protrudes and receives incoming bee

Honeysuckle Family—*Continued*

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-Fertilization, etc.
High Bush-Cranberry	Vibúrnum Ópulus	Small bees and flies	Insects cross-fertilize flowers merely by crawling over the clusters
Hobblebush	Viburnum lantanoìdes	Small bees (Andrena) and flies	Insects cross-fertilize flowers merely by crawling over the clusters
Common Elder	Sambùcus Canadénsis	Pollen gatherers, flies, beetles, and lesser bees	Stamens radiate away from stigma

Madder Family (*Rubiàceae*)

Partridge-berry	Mitchélla rèpens	Bees	Dimorphic blossoms
Button-bush	Cephalanthus occidentàlis	Bees and butterflies chiefly	Anthers mature before stigma. Peculiar method. The pollen is shed on the style before the buds open, but is carried away by insects before the stigma matures
Bluets	Houstònia cærùlea	Flies, bees, and butterflies	Dimorphic flowers

Teazel Family (*Dipsàceae*)

Wild Teazel	Dípsacus sylvéstris	Bumblebees	Anthers mature before the stigma

Composite Family (*Compósitae*)

As a family the Compositæ have developed two characteristics which insure cross-fertilization; the first is the method of grouping many small florets in one head, thus attracting the attention of insects by a great expanse of color; the second is the method described in the text under the cone-flower of ejecting their pollen from their tubes with the stigmas, which act as piston rods. After the pollen has been distributed the stigmas mature and are ready to receive foreign pollen.

Common Burdock	Láppa officinàlis	Butterflies and bumblebees	
Common Tansy	Janacètum vulgàre	Bees, flies, beetles, and butterflies	
Pearly Everlasting, or Immortelle	Antennària margaritàcea	Flies and beetles	Stigmatic flowers generally separate from staminate flowers
Iron-weed	Vernònia Noveboracénsis	Butterflies and long-lipped bees	
Common Blazing-star	Liàtris squarròsa	Long-tongued bees and flies	
Purple Thoroughwort, or Joe-Pye weed	Eupatòrium purpùreum	Butterflies chiefly (bees and flies)	Anthers mature before stigma
Thoroughwort, or Boneset	Eupatòrium perfoliàtum	Beetles, flies, wasps, and bees	

Supplement

Composite Family—*Continued*

Common Name	Scientific Name	Insect Visitor	Method of Preventing or Limiting Self-fertilization, etc.
Groundsel-bush or tree	Senècio vulgàris	Very few insects, bees chiefly	Stigmatic flowers frequently separate from staminate ones; self-fertilization usual, however, since many seeds are produced even in seasons unfavorable to insect visits
Golden Ragwort, or Squaw-weed	Senècio aùreus	Many insects	
Elacampane, or Horseheal	Ínula Helènium	" "	Disk florets contain both pistils and stamens, ray florets apt to be staminate only
Golden-Rods	Solidiàgo	" "	Disk florets contain both pistils and stamens, ray florets apt to be staminate only
Starworts, or Asters	Áster	" "	Self-fertilization frequent
Daisy-leaved Fleabane, or Robin's Plantain	Erígeron bellidifòlium	Bees and thistle butterfly	
Larger Daisy-Fleabane	Erígeron ánnuum	Many insects	Self-fertilization usual
Yarrow, or Milfoil	Achillèa Millefòlium	Bees, flies, butterflies, and beetles	
Common May weed, or Camomile	Marùta Cótula	Flies	Ray flowers neutral
Common Daisy	Chrysánthemum Leucánthemum	Numerous insects	Self-fertilization frequent in absence of insects
Sneezeweed	Helènium autumnàle	Flies, butterflies, and bees	Disk florets contain both pistils and stamens, many florets apt to be stigmatic only
Lance-leaved tick-seed, Golden Coreopsis.	Coreópsis lanceolàta	Flies and butterflies	Disk flowers perfect, ray-flowers without anthers or stigmas
Larger Bur-Marigold	Bìdens chrysanthemoìdes	Many insects	Disk flowers perfect, self-fertilization usual
Tall or Giant Sunflower	Heliánthus gigantèus	" "	Disk flowers perfect, self-fertilization usual
False Sunflower, or Ox-eye	Helióspsis laèvis	" "	Disk flowers perfect, self-fertilization usual
Black-eyed Susan, or Cone-Flower	Rudbéckia hírta	" "	Disk flowers perfect, self-fertilization usual
Orange or Tawny Hawkweed	Hieràcium paniculàtum	Flies and smaller bees	
Common Dandelion	Taráxacum Dens-leònis	Many insects	Flowers of early spring and of late fall not visited by insects, but are fertile, self-fertilization common

Composite Family—*Continued*

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Sow Thistle	Sónchus Arvénsis	Many insects	Self-fertilization common
Lobelia Family (*Lobeliàceae*)			
Great Blue Lobelia	Lobèlia syphilítica	Bumblebees	Anthers mature before stigmas. Stigmas protrude far beyond anthers
Campanula Family (*Campanulàceae*)			
Venus's Looking-glass	Speculària perfoliàta	Many insects	Produces both showy and cleistogamous flowers Anthers mature before stigmas
Common Harebell	Campánula rotundifòlia	Bees and butterflies (flies and beetles)	Anthers mature before stigma
Heath Family (*Ericàceae*)			
Trailing Arbutus, or Ground Laurel	Epigaèa rèpens	Female bumblebees, flies and bees	In a transition state, showing a tendency toward trimorphism
Common or Black Huckleberry	Gaylussàcia resinòsa	Small bees	Stigma protrudes and strikes incoming bee
Andromeda	Andrómeda floribúnda	Small bees	Stigma protrudes beyond anthers. See text
Mountain Laurel	Kálmia latifòlia	Bees	Anthers concealed in pocket. See text
American or Great Rhododendron	Rhododéndron máximum	Bees	
Purple Azalea, or Pinxter-flower	Azàlea nudiflòra	Female bees	Stigma protrudes and strikes incoming bee
Wintergreen	Pýrola rotundifòlia	Bees and flies	Stigma protrudes and strikes incoming bee
Spotted Pipsissewa	Chimáphila maculata	Bees and flies	Stigma stands above anthers
Holly Family (*Aquifolíaceae*)			
Mountain Holly	Nemopánthes Canadénsis	Several insects, no special visitor	Staminate flowers separate from stigmatic ones
Black Alder	Ilex verticillàta	Several insects, no special visitor	Staminate flowers separate from stigmatic ones
Primrose Family (*Prímulàceae*)			
Shooting Star, or American Cowslip	Dodecàthon Meàdia	Female bumblebees	Stigma protrudes and strikes incoming bee
Star-flower, or American Chickweed	Trientàlis Americàna	Pollen-collecting bees and flies	Stigma matures before the anthers

Primrose Family—*Continued*

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Lance-leaved Loosestrife	Lysimàchia lanceolàta	Female bees (macropis)	Stamens drawn away from style by expanding petals during time stigma is receptive
Common Pimpernel	Anagállis arvénsis	Pollen-collecting insects	Self-fertilization frequent

Bladderwort Family (*Lentibulàceae*)

Large Bladderwort	Utriculària vulgaris	Bees and flies	As soon as the incoming insect fertilizes the stigma, it rolls up to prevent contact with its own pollen

Bignonia Family (*Bignoniàceae*)

Wild Trumpet-flower	Técoma radìcans	Humming bird (Large moths)	Lobes of stigma close when touched

Broom-Rape Family (*Orobanchàceae*)

Beech-drops, or Cancer-root	Epiphègus Virginiàna	Several insects, no special visitor	Produces cleistogamous buds. Perfect flowers are sterile

Figwort Family (*Schrophulariàceae*)

Common Mullein	Verbáscum Thápsus	Pollen-collecting bees and flies	Stigma protrudes and strikes incoming bee
Culver's Root	Verónica Virgínica	Many insects	Anthers mature before the stigmas
Brooklime, or Water Speedwell	Verónica Americàna	" "	Anthers mature before the stigmas
Common Speedwell	Verónica officinàlis	" "	Growing in dense clusters, cross-fertilization is effected by insects crawling over the head
Blue-eyed Mary, or Broad-leaved Collinsia	Collínsia vérna	Pollen-collecting bees (Osmia)	Two sets of stamens (long and short) maturing at different intervals
Blue or Wild Toadflax	Linària Canadénsis	Long-tongued bees and butterflies	
Butter-and-Eggs, or Common Toadflax	Linària Vulgàris	Bumblebees and butterflies	Stamens of two lengths Self-fertilization possible
Large Purple Gerardia	Gerárdia purpùrea	Bees	Stigma protrudes beyond anthers
Downy False Foxglove	Gerárdia flàva	Bumblebees	Stigma protrudes beyond anthers and strikes incoming pollen-laden bee

Figwort Family—*Continued*

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Monkey Flower	Mímulus ríngens	Long-tongued bees	Two sets of stamens and sensitive stigma which rolls up after contact with visitor, exposing stamens which then shed their pollen
Figwort	Scrophulària nodòsa	Wasps	Stigmas mature before anthers. See text
Snake-head, or Balmony	Chelòne glàbra	Bumblebees	Anthers mature before stigma
Hairy Beard Tongue	Pentstèmon pubéscens	Long-tongued bees	Anthers mature before stigmas
Scarlet Painted Cup	Castilleia coccínea	Humming birds	
Wood Betony	Pedicularís Canadénsis	Bees	See text

Acanthus Family (*Acanthàceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Hairy Ruéllia	Ruéllia ciliòsa	Many insects	Bears both showy and cleistogamous flowers

Vervain Family (*Verbenàceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Blue Vervain	Verbèna hastàta	Bees and butterflies	

Mint Family (*Labiàtae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Spear Mint	Méntha víridis	Many insects	Anthers mature before stigmas
Horsebalm	Collinsònia Canadénsis	Bumblebees	Stigma matures before anthers
Creeping Thyme	Thýmus Serpýllum	Bumblebees, flies, and butterflies	Some flowers perfect, others stigmatic, others staminate
Oswego Tea, or Bee-Balm	Monárda dídyma	" "	
Wild Bergamot	Monárda fistulòsa	" "	Anthers mature before stigmas
Ground Ivy	Népeta Glechòma	Many insects	Anthers and stigmas mature at different periods in larger flowers, small flowers stigmatic only
False Dragon-Head	Physostègia Virginiàna	Bumblebees	Anthers mature before stigma
Self-Heal, or Heal-all	Brunélla vulgàris	Bumblebees	Anthers mature before stigma
Skullcap	Scutellària laterifiòra	Bees	Anthers mature before stigma
Common Motherwort	Leonùrus Cardìaca	Bumblebees	Two lengths of stamens

Supplement

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Borage Family (*Borraginàceae*)			
Viper's Bugloss	Èchium vulgàre	Sixty-seven species of insects	Anthers mature before stigma
Virginia or Smooth Lungwort, or Cowslip	Merténsia Virgínica	Many insects	Anthers widely separated from stigma
True Forget-me-not	Myosòtis palústris	Flies or bees	Anthers and stigma so arranged that they are touched by opposite sides of the tongue of the visiting insect. Self-fertilization possible
Common Houndstongue	Cynoglóssum officinàle	Bees and butterflies	Self-fertilization possible
Beggar's Lice	Cynoglóssum Morisòni	Pollen-gathering bees	See text
Waterleaf Family (*Hydrophyllàceae*)			
Virginia Waterleaf	Hydrophýllum Virgínicum	Bumblebees	Anthers mature before stigma
Polemonium Family (*Polemoniàceae*)			
Sweet William	Phlox maculàta	Butterflies chiefly	Anthers mature before stigmas, but self-fertilization is common
Downy Phlox	Phlox pilosa	" "	Anthers mature before stigmas, but self-fertilization is common
Ground or Moss Pink	Phlox subulata	" "	Anthers mature before stigmas, but self-fertilization is common
Convolvulus Family (*Convolvulàceae*)			
Morning-glory	Ipomœa purpùrea	Bees	Stigma matures before anthers
Wild Potato Vine	Ipomœa panduràta	Bumblebees	
Field Bindweed	Convólvus arvénsis	Bees, flies, and beetles	Stigmas protrude beyond anthers. Self-fertilization possible owing to drooping position of flower
Great Bindweed	Calystègia sèpium	Bees, moths, and flies	Self-fertilization possible
Nightshade Family (*Solanàceae*)			
Black or Common Nightshade	Solànum nìgrum	Pollen-gathering female bumblebees chiefly	
Ground Cherry	Phýsalis Pennsylvánica	Bees	Stigma matures before anthers, also protrudes beyond them
Common Thorn-apple	Datùra Stramònium	Sphinx moth	

Supplement

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Gentian Family (*Gentianàceae*)			
Rosy Centaury	Sabbàtia angulàris	Many insects	Anthers mature before stigma and open outward
Fringed Gentian	Gentiàna crinìta	Bees and bumblebees	Anthers mature before stigma and open outward
Closed or Blind Gentian	Gentiàna Andréwsii	Bumblebees	Anthers mature before stigma and open outward
Dogbane Family (*Apocynàceae*)			
Spreading Dogbane	Apócynum Androsæmifòlium	Bees, flies, and butterflies	Pollen concealed in V-shaped cavity well away from stigma
Indian Hemp	Apócynum cannábinum	Bees, flies, and beetles	Pollen secreted well away from stigmatic cavity
Milkweed Family (*Asclepiadàceae*)			
Butterfly-weed	Asclèpias tuberosa	Butterflies	Pollen concealed in V-shaped cavity well away from stigma
Common Milkweed	Asclèpias Cornùti	Bees, flies, and butterflies	Pollen concealed in V-shaped cavity well away from stigma
Birthwort Family (*Aristolochiàceae*)			
Wild Ginger	Ásarum Canadénse	Flies	Stigma matures before anthers
Pokeweed Family (*Phytolaccàceae*)			
Pokeweed	Phytolácca decándra	Bees and flies	Anthers generally mature before stigma
Buckwheat Family (*Polygonàceae*)			
Common Persicària	Polýgonum Pennsylvánicum	Bees and flies	
Lizard's-Tail Family (*Saururàceae*)			
Lizard's-tail	Saurùrus cérnuus	Flies	
Laurel Family (*Lauràceae*)			
Spicebush	Líndera Benzòin	Many insects	Stigmatic flowers generally separate from staminate ones
Spurge Family (*Euphorbiàceae*)			
Flowering Spurge	Euphórbia corollàta	Flies	Staminate flowers separate from stigmatic ones

Supplement

Arum Family (*Aràceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-Fertilization, etc.
Jack-in-the-Pulpit or Indian Turnip	Arisæma triphýllum	Gnats and other insects	Stigmatic flowers generally separate from staminate flowers. In transition stage becoming diœcious
Water Arum	Cálla palústris	Small insects, midges, etc.	Lower flowers staminate and stigmatic. Upper flowers staminate only Stigma matures before anthers
Skunk or Swamp Cabbage	Symplocárpus fœtidus	Flies	Stigma matures before anthers. Anthers turned away from pistil. Odor unpleasant
Golden Club	Oróntium aquáticum	Flies and midges	Cross-fertilized by insects crawling over it

Water-Plantain Family (*Alismàceae*)

Water Plantain	Alísma Plantàgo	Flies	Stamens radiate away from stigma
Broad-leaved arrow-head	Sagittària variábilis	Bees and flies	Stigmatic flowers separate from staminate ones

Pickerel-Weed Family (*Pontederiàceae*)

Pickerel-Weed	Pontedèria cordàta	Bees and flies	Trimorphic

Orchis Family (*Orchidàceae*)

Showy Orchis	Orchis spectábilis	Female bumblebees	See text
The Purple-Fringed Orchid (smaller)	Habenària psycòdes	Butterflies	See text
The Ragged Orchid	Habenària lácera	Butterflies	See text
The Great Green Orchis	Habenària orbiculàta	Butterflies and smaller moths	See text
The Rattlesnake Plantain	Goodyèra	Bees	See text
Arethusa	Arethùsa bulbòsa	"	See text
Pogonia	Pogònia ophioglossoìdes	"	See text
Moccasin Flower	Cypripèdium acaùle	Bees and bumblebees	See text

Amaryllis Family (*Amaryllidàceae*)

Yellow Star Grass	Hypóxis eréeta	Small bees and flies	Stamens radiate away from stigma

Smilax Family (*Smilàceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Carrion Flower	Smìlax herbàcea	Green flesh flies	Staminate flowers separate from stigmatic ones

Iris Family (*Iradàceae*)

Larger Blue Flag	Íris versícolor	Bees and bumblebees	Stigmatic surface covered by flexible flap, which insect opens as it withdraws proboscis and body from flower. Anthers face away from stigma

Lily Family (*Liliàceae*)

Great Flowered White Trillium	Tríllium grandiflòrum	Bees	Anthers mature before stigma
Purple Trillium, or Birthroot	Tríllium eréctum	Green flesh flies and beetles	Evil smelling. Self-fertilization possible.
Nodding Trillium	Tríllium cérnuum	Bumblebees	Anthers mature before stigma
Indian Cucumber-root	Medèola Virgínica	No special visitor, many insects	Styles much longer than stamens
Blazing Star, or Devil's Bit	Chamælírium lùteum	Several insects, no special visitor	Stigmatic flowers on separate plants from the staminate ones
American White Hellebore	Veràtrum víride	Flies	Anthers mature before stigmas
Bellwort	Uvularia perfoliàta	Female bees bumblebees	Stigma protrudes beyond anthers; strikes incoming bee
Wild Spikenard, or False Solomon's Seal	Smilacìna racemosa	Bees	Stigma matures before anthers
Smaller Solomon's Seal	Polygonàtum biflòrum	Bees	Self-fertilization quite frequent
Wild Orange-Red Lily	Lílium Philadélphicum	Pollen-gathering bees	
Canada Lily	Lílium Canadénse	Pollen-gathering bees, butterflies	Drooping position of flower renders self-fertilization difficult
Turk's Cap	Lílium supérbum	Pollen-gathering bees, butterflies	Drooping position of flower renders self-fertilization difficult
Yellow Adder's Tongue, or Dog-tooth Violet	Erythrònium Americànum	Small bees, butterflies, and flies	Self-fertilization common
Wild Hyacinth	Scilla Fràseri	Bees, flies, and butterflies	

Spiderwort Family (*Commelynàceae*)

Common Name	Scientific Name	Insect Visitors	Method of Preventing or Limiting Self-fertilization, etc.
Virginia or Common Day Flower	Commelyna Virgínica	Pollen-collecting bees	
Spiderwort	Tradescántia Virgínica	Pollen-collecting bees	Stigma separated from anthers, extending so far beyond them that self-fertilization is improbable